Biomass to Ethanol Process Evaluation

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TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

Page

I EXECUTIVE SUMMARY

Chem Systems has been commissioned to perform a technical and economic evaluation of the plant design described in the SERI draft report entitled "Technical and Economic Analysis of an Enzymatic Hydrolysis Based Ethanol Plant" dated 1991. In addition Chem Systems has been asked to examine the effect of selected process improvements on the cost of production of ethanol. It has been assumed that these improvements could be attained through R&D on the feedstock and the conversion process and through operational experience on scaled-up processes. The 1991 SERI analysis determined a base case product cost of $1.27 per gallon of ethanol product, and a target product cost of $0.67 per gallon.

Using the SERI report as a basis and starting point, Chem Systems developed a heat and material balance for the wood-to-ethanol process using its own process and engineering design experience and a process simulator computer software program licensed to Chem Systems. This program also generated most of the equipment size specifications. The design basis parameters included data on feedstock composition, as well as yield, operating conditions and material balance for prehydrolysis and hydrolysis reaction, fermentation, and enzyme production. Based on a 580 thousand metric tons per year (160,000 pounds per hour) of wood (dry) feed rate at a 1993 southeast US location, investment capital (both inside and outside battery limits) and production costs have been estimated.

To improve the usefulness and accuracy of the model as a tool for carrying out sensitivities, Chem Systems has developed algorithms that generate equipment cost estimates as a function of material balances flows. These have been used to generate the total investment cost for a specific sensitivity. In addition to the capital cost algorithms, production costs algorithms have also been developed. These algorithms have proved to be a useful vehicle for conducting extensive sensitivity analysis in the past for NREL (SERI).

An economic analysis has been performed on a fuel ethanol (90 percent ethanol, 5 percent water, and 5 percent gasoline) plant producing approximately 160 thousand metric tons per year (54 million gallons per year). The feedstock to the plant is assumed to be whole-wood tree chips delivered to the site at a cost of $46 per dry metric ton ($42 per short ton).

The capital investment is provided in the appendix and summarized in Table I.1. At this level of detail the capital cost estimate is judged to have an accuracy of plus or minus 25 percent. The purchased equipment for the ISBL totals $25 MM and the corresponding installed cost is estimated to be $40 MM. The major investment in this area is the SSF facilities having an installed cost of over $17 MM. In the off-site area the major investment item is the boiler package (circulating fluid-bed boiler, BFW system and bag house) which is expected to cost about $27 MM (installed). The total installed plant cost (both ISBL and OSBL) is estimated to be $101 MM. Adding in the indirects to this total gives a total capital investment of $150 MM. The total project investment including the owner's other project costs is estimated to be $165 MM.

TABLE I.1
INVESTMENT COST SUMMARY - BIOMASS TO ETHANOL PLANT
(millions dollars, 1993 basis)

	Plant Area		Installed Equipment
ISBL	100	Wood handling	3.20
	200	Prehydrolysis	7.75
	300	Xylose fermentation	3.19
	400	Cellulase production	1.74
	500	SSF	17.68
	600	Ethanol recovery	6.49
		Total	**40.05**
OSBL	700	Off-site tankage	2.12
	800	Waste treatment	6.09
	900	Utilities	
		Boiler package (including BFW system)	26.61
		Process water	0.45
		Turbogenerator	9.19
		Cooling water package	3.08
		Chilled water package	1.23
		Plant, instrument and fermentation air	5.33
		CIP/CS	0.30
		Buildings	1.60
		Site development	3.60
		Additional piping	1.80
		Total	**61.38**
Indirects	Prorateable costs		10.14
	Field expenses		10.14
	Home office construction and fees		25.36
	Contingency		3.04
	Total capital investment		150.12
	Owner's costs		15.01
	Total project investment		**165.13**

A detailed cost of production estimate is provided in Section VI and summarized in Table I.2. The net raw materials is estimated to be $208 per metric ton (62 cents per gallon). Utilities are estimated to provide a credit of about $33 per metric ton (10 cents per gallon). The total variable cost is $175 per metric ton (52 cents per gallon).

TABLE I.2
COST OF PRODUCTION SUMMARY
(US$ per metric ton)

Raw materials	205
By-product credits	3
Net raw materials	**208**
Utilities	(34)
Variable cost	**175**
Direct fixed costs	26
Allocated fixed costs	21
Total cash cost of production	**222**
Annual capital charges	207
Cost of denatured ethanol	**430**

Adding in the direct fixed costs ($27 per metric ton) and allocated fixed costs ($21/per metric ton) gives a total cash cost of production of $222 per metric ton or 66 cents per gallon.

Adding in the annual capital charge (20 percent of total investment) almost doubles the production cost. The resulting cost of denatured ethanol is $430 per metric ton or $1.27 per gallon. This corresponds very closely with the results of the 1991 SERI report.

The report prepared in 1991 by SERI examined numerous parameters and their influence on the biomass process. In order to approach the target of 67 cents per gallon, in this study several improvements have been combined within one sensitivity. The changes to the base case can be grouped into three categories (see Table I.3):

- Technology improvements (yields, fermentation times, equipment, ethanol concentrations, enzyme loading, etc.)
- Feedstock production improvements (cost and content)
- More optimistic cost of production factors (electricity selling price and onstream time)

TABLE I.3
PROCESS PARAMETERS AND ASSUMPTIONS

	Base Case	Sensitivity (goal)	my [illegible]
Cellulose to ethanol yield, %	75.7	90	90
Xylose to ethanol yield, %	85.5	95	90
Xylan to xylose yield, %	80.0	90	95
SSF fermentation time, days	7	3	2
Xylose fermentation time, days	2	1	
Ethanol concentration in SSF, %	4.17	6	
Cellulase loading, IU/g	7	3	3
SSF and xylose seed fermentations	yes	eliminated	
Feedstock cost, $/dry ton (short)	42	34	34
Feedstock carbohydrate content, %	70.2	77.2	—
On-stream time, %	91.3	98	98
Electricity selling price, cents/KWH	4.2	6	4
Ethanol purification	distillation	mole sieve	

The flow scheme for the sensitivity case remained essentially unchanged from the base case except for the distillation section where a pressure swing adsorption unit (mole sieve) has been used in place of the rectifying column to bring the concentration of ethanol from 4.7 to 94.5 percent in the final product.

The results of the sensitivity case shows a savings in investment of $25 million in the total capital investment or about 15 percent less than the base case. The yield or production of ethanol per unit of wood feedstock has increased by about 30 percent over the base case. The consumption of utilities improved in all areas. The estimate of the cost of production shows that the cost has been lowered to $251 per metric ton (74 cents per gallon).

As a result of this study, Chem Systems has concluded that the overall process concept appears to be feasible and is generally supported by reasonable engineering judgement. Areas that need further investigation and substantiation include:

- The affect of the solids concentration in the feed to the on the distillation system
- The affect of the high pH on the fermentation tanks and finding a suitable lining for the same
- Development/verification of the sensitivity case assumptions (e.g., yields, etc.) in order to achieve reasonable plant economics
- Verify large scale equipment feasibility

If, in addition to the improvements discussed and implemented in this report, efforts are made to reduce power consumption, to continue to optimize other aspects of the process, and to increase the carbohydrate content of the feedstock, one could expect the ethanol price to be reduced even further.

II INTRODUCTION

A. BACKGROUND

In 1991 the National Renewable Energy Laboratory (NREL) developed a technical and economic analysis for a commercial scale plant producing ethanol from biomass. This study conducted by the Solar Energy Research Institute (SERI) draft report was entitled "Technical and Economic Analysis of an Enzymatic Hydrolysis Based Ethanol Plant." More specifically, the design is for a fuel grade ethanol plant based on wood as the feedstock. This analysis is based on earlier work for the Ethanol Program of the U.S. Department of Energy's (DOE) Biofuels Division. The objective of the 1991 study was to incorporate the latest R&D developments into the bases of the design. The purpose of this study is to update and validate the results of the 1991 report based on a more detailed engineering analysis.

B. ISSUES AND OBJECTIVES

Chem Systems has been commissioned to perform a technical and economic evaluation of the plant design described in the SERI draft report entitled "Technical and Economic Analysis of an Enzymatic Hydrolysis Based Ethanol Plant." In addition Chem Systems has been asked to examine the effect of process improvements on product cost. It has been assumed that these improvements could be attained through R&D on the feedstock and the conversion processes and through operational experience on a scaled-up processes. The 1991 SERI analysis determined a base case product cost of $1.27 per gallon of ethanol product, and a target product cost of $0.67 per gallon.

NREL's current objective is to conduct an independent technical and economic evaluation of the plant design and a sensitivity analysis for a biomass-to-ethanol plant. This includes:

- The independent development of a process design using NREL's existing design parameters.
- The development of investment and production economics.
- Economic sensitivities as a function of design and operating parameters.

Specifically Chem Systems objectives are to:

- Check that the low price of ethanol derived in the SERI report can be achieved.
- Confirm the reasonableness of NREL's process design from an engineering standpoint.
- Inform NREL as much about Chem Systems' methodology as possible (including assumptions, simulator convergence techniques, cost estimating techniques, cost algorithms, etc.).

C. METHODOLOGY

Using the SERI report as a basis and starting point, Chem Systems has developed a heat and material balance for the wood-to-ethanol process using its process design experience and a process simulator computer software program licensed to Chem Systems. This program also generated most of the equipment size specifications. The design basis parameters included data on feedstock composition as well as yields, operating conditions and material balance for prehydrolysis and hydrolysis reactions, fermentation, and enzyme production. Based on a 580 thousand metric tons per year (160,000 pound per hour) of wood (dry) feed rate at a southeast US location, investment capital (both inside and outside battery limits) and production costs have been estimated.

To improve the usefulness and accuracy of the model as a tool for carrying out sensitivities, Chem Systems has developed algorithms that will generate equipment cost estimates as a function of material balance flows, which will be used to generate the total investment cost for a specific sensitivity. In addition to the capital cost algorithms, production costs algorithms have been developed. These algorithms have proved to be a useful vehicle for conducting extensive sensitivity analyses in the past for NREL (SERI).

1. Process Configuration (Section III)

Starting with the SERI report as a basis and starting point, Chem Systems has used its own process engineering judgement, as well as industry expert input and vendor information to determine the final process design/configuration.

2. Process Simulation (Section IV)

The heat and material balance for the final ethanol-to-biomass process has been simulated using a computer model (CHEMCAD III) licensed by Chemstations, Inc. A complete heat and material balance has been produced for the onsite unit operation of the base case and has included the development of utility requirements. Similarly, the steam system has been simulated using CHEMCAD.

3. Equipment Sizing (Section V)

The CHEMCAD program has been used to size most of the equipment used in the ethanol-to-biomass process. Equipment not sized or handled by this program, has been sized manually by Chem Systems engineers for cost estimating purposes and for use in the appropriate cost algorithms.

4. Cost Model (Section VI)

The equipment cost has been estimated through a combination of vendor quotes, licensed computer software and in-house data. The cost of several specialized equipment items was estimated based on vendor quotes. From this, the total capital investment for each plant section has been estimated based on using appropriate factors on the equipment cost to get field installed cost and then total plant cost. To this, value Chem Systems has added representative project costs such as owner costs, start-up expenses, working capital, etc. to develop the total project cost.

The production costs estimate has been developed using the heat and material balance data to determine raw material, product, by-product and utility consumptions. The labor, maintenance and overhead costs have been based on typical industry rates.

5. Sensitivity Analysis (Section VII)

A sensitivity analysis has been prepared for a combination of parameters (e.g., yield, fermentation time, ethanol concentration, etc.) in an attempt to achieve an ethanol cost of 67 cents per gallon.

III PROCESS DESIGN

A. BASE CASE (as represented in SERI report)

The starting point for this evaluation is the design as presented in the 1991 SERI report and modified during the course of this study by Chem Systems for operability and by NREL based on their latest knowledge and understanding of the process.

The base SERI process takes wood chips, which are delivered to the plant and stored in a large pile, and then conveys the wood to the disk refiner where it is reduce in size. The milled chips are sent to a prehydrolysis reactor which includes treatment with dilute sulfuric acid for the conversion of a large fraction of the wood xylans to xylose. Recycle water is added to the mixture after a blowdown tank to reduce the solids concentration to a level that can be pumped to the neutralization tank. The sulfuric acid is then neutralized with lime and the resulting slurry, including the precipitated gypsum is cooled and sent to xylose fermentation. The xylose is converted to ethanol by a genetically engineered *E. coli*. This diluted ethanol and cellulose/lignin stream is sent to cellulose fermentation where cellulose is converted to ethanol by the SSF process.

A small fraction of the neutralized stream is sent to the sterile feed tank for feed to the cellulase production fermenters where the fungus *T. reesei* consumes the cellulose and produces cellulase. In addition, nutrients and corn steep liquor are mixed and sterilized in a separate tank and then added to the cellulase fermenters. After the batch cellulase fermentation is complete, the broth is pumped to the cellulase hold tank from where it is pumped continuously to the simultaneous saccharification and fermentation (SSF) reactor. The cellulase enzyme catalyzes the hydrolysis of cellulose to glucose, which is then consumed by the yeast to produce ethanol all in the same reactor. The fermentation to ethanol is carried out by a mixed culture of *Sacchromyces cerevisiae* and *Brettanomyces clausenii.*

The dilute ethanol stream from the SSF reactors is sent to ethanol purification where a distillation operation produces 95 weight percent ethanol. The waste stream from the bottom of the beer column is sent to centrifugation to remove the lignin and unreacted solids, which are then sent to the boiler. A fraction of the liquid stream from the centrifuge is recycled back to the process and the rest is sent to waste treatment to be purified and then recycled back to the process water system.

The facility requires several utility generation and offsite systems including:

- A co-generation system (steam boiler, boiler feedwater system and turbogenerator)
- A process water system
- Plant and instrument air, fermentation air
- A chilled water system
- A low-pressure vent system
- Off-site tankage
- A clean-in-place and chemical sterilization system (CIP/CS) for the fermenters

The major parameters that have been revised by NREL during the preparation of the Chem Systems' design are summarized below and described in detail in Section B:

- The feed has been specified to expand the component xylan to include galactan, arabinan and mannan and their associated sugars (galactose, arabinose and mannose). The appropriate yield data has been provided by NREL.
- The acid concentration in the prehydrolysis effluent is regulated to be 0.85 weight percent of the water leaving the reactor.
- The dilution water is regulated to provide a biomass concentration of 35 weight percent leaving the prehydrolysis flash tank.
- The process water makeup has been moved from before the recycle loop (mixed with water from lignin separator) to after the wastewater treatment area. This increases the recycle water temperature to about 95°F.

- *B. clausenii* (BC) is no longer produced. In addition the BC seed fermentation line has been removed from the design.

- The impregnation reactor has been eliminated and replaced with the pilot plant design by Sunds Defibrator, Inc.

- SSF seed air rate has been cut in half to reflect only one seed train now in operation (versus two in the SERI design).

Other changes made by NREL that were made during the course of the development of the heat and material balance include:

- Mannan and galactan which were originally specified to have a conversion in the prehydrolysis reactor of 3 percent have been changed to have a conversion of 80 percent.

- No C_5 sugars are being converted in the SSF Seed Fermenters.

- Mannan and galactan are now converted at 80 percent in SSF, not 87 percent like cellulose.

- From an economic point of view, higher pressures and temperature have become more accepted for industrial power plant design in the last 10-20 years. Thus, 1,500 pound steam boiler has been used in place of the 1,100 psig boiler in the 1991 base case.

- The acetaldehyde conversion has been reduced to 0.5 percent

B. CHANGES TO THE SERI BASE CASE

1. Process

After review of the 1984 SERI report, several unit operation modifications, additions and deletions were made to address operability concerns. These changes are described in more detail below. Some modifications were also provided by NREL. Since the issuance of the 1991 SERI report, more research has been done on the process, and new data has been made available for process design. The detailed process design is given in Section D. Equipment numbers referenced in this section can be found on the process flow sheets in Section IV and in the equipment list in Appendix V. A block diagram of the overall process configuration is shown in Figure III.B.1.

(a) Changes to SERI Design Basis

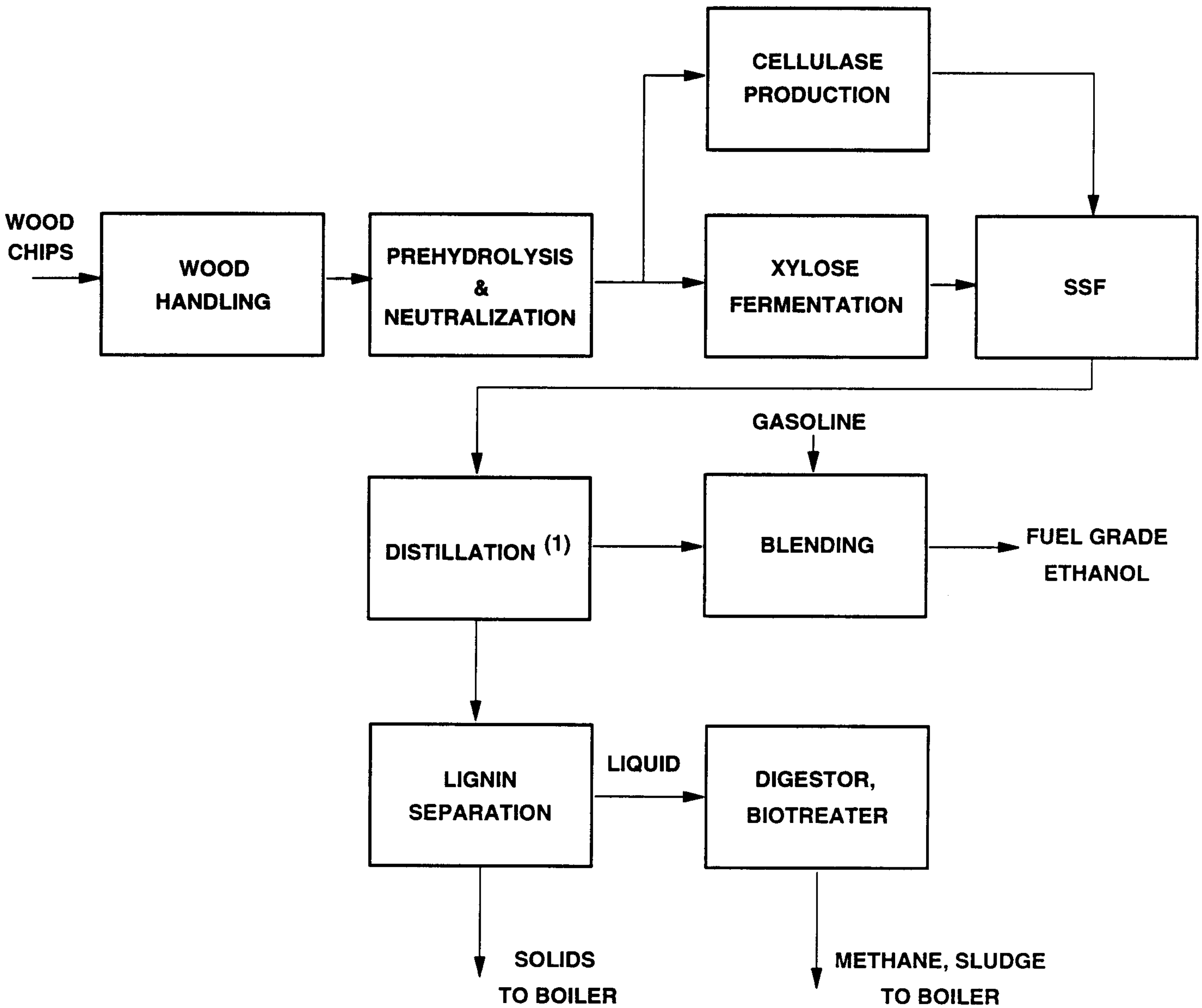
NREL provided several modifications to the original design basis, based largely on research results since 1991.

(1) Wood Composition

Feed composition of the wood has been modified to include more C_5 and C_6 hemicelluloses, as well as C_5 and C_6 sugars. Cellulose composition remains the same, while xylan has been broken out into the hemicellulosic components: xylan, mannan, galactan, and arabinan. The modified wood composition (dry basis) is as follows:

Cellulose:	46.20 wt%
Xylan:	18.05 wt%
Arabinan:	1.35 wt%
Galactan:	1.04 wt%
Mannan:	3.56 wt%
Lignin:	24.00 wt%
Soluble solids:	5.60 wt%
Ash:	0.20 wt%
Total:	**100.00 wt%**

FIGURE III.B.1
BLOCK FLOW DIAGRAM
ETHANOL FROM WOOD PROCESS



(1) SEPARATION TO AZEOTROPIC ETHANOL

S

Each cellulose and hemi-cellulose will hydrolyze into their corresponding sugar: cellulose to glucose, xylan to xylose, arabinan to arabinose, mannan to mannose, galactan to galactose. Under hydrolysis conditions the hemicellulosic components are assumed to act like xylan, whether pentosan or hexosan. The pentoses are assumed to ferment like xylose, and the hexoses like glucose. The pentoses are assumed to ferment like xylose, and the hexoses like glucose. *B. Clausenii* is no longer used as an inoculum.

(2) Cellulose Fermentation Inoculum

Only one organism is grown in the SSF seed fermentation process: *S. Cerevisiae*.

(3) Xylose Ammonia Requirements

Ammonia is used for pH control in the xylose fermentation area. Since no data was provided to update neutralization requirements, specifically for acetic and other acid formation in the xylose fermentation reactions, ammonia requirements have been assumed to be 0.0296 kg NH_3 per kg ethanol produced in xylose fermentation. This is based on lower theoretical acid and fermentation byproduct yields.

(4) Lignin Concentration

After the beer still, lignin is concentrated from the beer still bottoms before being sent to the boiler for use as the main source of plant fuel in the co-generation unit and utility boilers. The 1991 SERI report indicated that the cyclone concentrated lignin to a 50 weight percent slurry. This has been modified per NREL's request to a 40 weight percent concentration of lignin in water which is to be sent to the boiler as fuel. The lignin separation area (Area 630) and the boiler/co-generation unit have been modified accordingly.

(b) Design Basis Data

No significant modifications have been made to the design basis data.

2. Engineering

Several engineering modifications were made to the 1991 SERI report in order to address several operability issues. In some cases, designs supplied in the 1991 report would have led to significant down time due to Chem Systems' perceived process inoperability. Changes were instituted to address these issues.

While there remains much engineering work before this process can be actually translated into a working plant, the modifications presented below should provide a realistic basis for a working process. There remains many opportunities for engineering improvements, such as heat integration and pilot plant data, which would result in higher yields and lower operating costs.

(a) Soaking vs. Wash of Wood Feed

It was determined that soaking the wood chips before storage in the feed pile would cause several problems, most notably causing some composting of wood at the bottom of the chip pile. A secondary step would also be necessary to wet the chips before being fed into the disk refiner.

Chips will be stored dry in the pile. They will not be washed prior to storage on the pile to reduce composting in the bottom of the pile. From the storage pile, the chips are sent to the continuous chip washer before they are conveyed to the disk refiner.

(b) Cooling Water Approach Temperature

Approach temperatures in process heat exchangers used in the 1991 report are, in some cases, too tight. While 30°C availability is reasonable for cooling tower water, this temperature can fluctuate significantly with seasonal and even daily environmental variations. It is not uncommon to have 30°C "available" water actually above 35°C.

The approach temperatures in the heat exchangers have, therefore, been limited to 5°C for cooling water (corresponding to a minimum process cooling outlet of 35°C) and 3°C for chilled water (corresponding to a minimum process cooling outlet of 13°C). On hot days, achieving 37°C in the fermentation areas may be problematic with cooling tower water as coolant.

Due to the changes, a few of the heat exchangers in the 1991 report have been switched to chilled water, while others have been added to account for the limit in cooling tower water capabilities.

(c) Addition of Water Scrubber

The 1984 report indicates the use of chilled water vent condensers for the recovery of ethanol from CO_2 fermentation offgas. Vent condensers are inefficient, especially for the recovery of volatile organics from warm, dilute air or gas streams. With the chilled water system presently used, recovery of ethanol from these streams would probably not exceed 70 percent.

General industry practice, in cases where a solvent needs to be recovered from a dilute air stream, is to use a scrubbing system. These have extremely high efficiencies, in many cases recoveries can exceed 99 percent. The vent condensers in the 1991 SERI report have been replaced with a ethanol-containing vent manifold to a water scrubber. The scrubber has been designed for a 95 percent ethanol recovery, using process water as the absorbent phase.

The scrubber water, rich with ethanol, is sent to the distillation area for ethanol purification, while the scrubber gases are sent to the boiler for incineration. There had been some discussion regarding the recycle destination of the scrubber water. Since the vents contain significant impurities, such as HMF, methanol, acetaldehyde, etc., if the scrubber water is sent back before distillation these impurities would build up in the fermentation area. It was felt such a build up would be undesirable. The scrubber water have thus been sent to the beer still for ethanol recovery. The scrubber water should account for less than 10 percent of the beer still traffic.

The increased operating costs due to additional water in the ethanol purification columns is offset by the reduced operating costs from lower chilled water loads, improved ethanol recovery and lower capital costs (one low-cost scrubbing tower vs. several high-surface-area heat exchangers).

(d) Improved Ethanol Purification

The 1991 SERI report significantly undersized the distillation columns required for ethanol purification. The 1991 report indicated reflux ratios of less than 1 for both towers, and only 16 and 24 trays for the beer still and rectification column, respectively. Industry practice is to specify a minimum reflux ratio of 1.2, and simulations indicated a minimum of 40 trays per column was necessary for adequate separation. The report also seemed to ignore the fate of volatile fermentation by-products such as methanol, acetaldehyde, and acids. These light ends need to be removed from the ethanol stream; even though they have fuel value, they adversely affect Reid Vapor Pressure and may cause the ethanol to not meet government or other purity specifications.

The first column remains a beer still. Using a moderate reflux ratio (2.0), overheads are purified to approximately 0.66 weight percent ethanol, while the bottoms leave with less than 10 ppm ethanol. One pass sieve trays are used to keep the column diameter under four meters (maximum highway transportation width) and to minimize tray fouling and plugging due to the presence of solids.

The second column rectifies the beer still overheads to 94.7 weight percent ethanol (near azeotropic concentration). Bottoms once again contain under 10 ppm ethanol. The rectification still bottoms are sent to wastewater treatment. From a middle tray in the rectification still fusel oils are removed. Fusel oils are fermentation byproducts, typically amyl and isoamyl alcohol, with smaller quantities of branched 3- to 5-carbon secondary alcohols. These fusel oils tend to fall out of the water/ethanol solution at one tray, where they accumulate if they are not removed. The fusel oils are removed, washed with recycle water at a ratio of 10 to 1, then sent to the boiler for use as supplemental fuel.

Volatile fermentation byproducts such as acetaldehyde and methanol are removed using a vapor purge from the overheads of the rectification still. These vapors are burned in the boiler as supplemental fuel.

(e) Water Balance Optimization

Water use has been estimated for each area. Overall, a total recycle of wastewater is used to reduce overall water consumption. Because of water losses in the cooling tower, as well as vent losses, makeup water is provided from an on-site well or river source.

The recycle water is distributed by the recycle water pump (PP-631). The composition of the recycle water has been estimated using model simulation convergence. Convergence criteria was set at a less than 5 percent change between iterations. The recycle water is no longer refreshed with makeup water; makeup water is now mixed with water from wastewater treatment before recycle to utilities and wood washing. Fresh water is used also as the scrubber absorbent and for lime slurry dilution.

(f) Materials of Construction

In general carbon steel construction has been utilize throughout the plant consistent with the SERI report except where it would deemed to be inadequate either due to corrosion or other reasons as explained below. The following items have been upgraded from carbon steel:

Cellulase Fermenter, FM-400	Lined CS (or SS if less than 2 m^3)
Cellulase Seed Fermenter, FM-401-4	Lined CS (or SS if less than 2 m^3)
SSF Seed Fermenters, FM-501-5	Lined CS (or SS if less than 2 m^3)
SSF Fermenters, FM-500	Lined CS (or SS if less than 2 m^3)
Sulfuric acid storage tank, T-703	Fiberglass (CS inadequate)
Beer transfer pump, PP-505	SS

The cellulase and SSF fermenters have been upgraded based on the knowledge that the pH cold be as low as 3.5 in these tanks (re. page 15 of SERI report). Although the specific lining has not been specified it is assumed that a suitable lining will be developed by the time this technology becomes commercial. (The cost has been estimated based on data provided by NREL). The small vessels associated with the fermenters have been specified as stainless steel in based on ease of manufacturing. The corresponding pumps have been upgraded to stainless steel to be consistent.

(g) Lime Handling

The SERI 1991 design for lime addition would result in frequent shutdowns, poor control, and in general lacked operability. Lime is a naturally hydrophilic substance; the material clumps and is in general extremely difficult to move using traditional solids handling equipment. Frequent plugging would occur in both the Vacuumax transfer line and the rotary valves. Controlled addition necessary for accurate neutralization is realistically not practical.

The lime addition system has been reconfigured to minimize solids handling problems. Lime is still delivered via hopper rail car to the lime unloading pit (MF-224). However, a slurry storage tank (T-720) has been added; lime is dumped from the rail car via the unloading conveyor (GS-223) to the slurry lime tank, where it is mixed with an equal amount of fresh makeup water. The 50 percent slurry is then sent to a day tank. The slurry is then metered via the slurry pump (PP-221) to the neutralization tank (T-206).

This method incurs approximately the same capital cost requirement as the 1991 design, while eliminating the many problems associated with solids handling.

(h) Heat Integration/Optimization

Extensive heat integration in the ethanol purification area has been employed to reduce overall steam consumption. Flash vapor from are 200 (prehydrolysis), in combination with beer still bottoms, have been used to preheat the beer still mash feed. In addition, the beer still is operated at a higher pressure so that the overhead condenser can act as the rectification still reboiler.

These integration modifications, along with sensitivities, are discussed in more detail in Section IV and V.

(i) Impregnator Design

The impregnator was not simulated on the process model. The prehydrolysis reactor was assumed to provide 100 percent of the reaction time necessary for prehydrolysis. No data was available to model wood reactions in the impregnator section (MR-201).

(j) Gypsum Plating

Due to the use of lime as a neutralizing agent for sulfuric acid, gypsum is produced. Gypsum solubility, therefore, required close monitoring to keep track of plating problems. In most cases, the area most susceptible to plating problems is the beer still reboiler, where vaporizing water can induce gypsum plating on the tube walls. A spare reboiler was added to minimize downtime due to boiler gypsum plating.

The engineering will include a manual check for salt solubilities, and make appropriate breakdowns into soluble and insoluble gypsum. Appendix V lists the gypsum balance for the process.

(k) Size of Fermentation Tanks and Mixing Requirements

Mixing requirements for the fermentation tanks, based on discussions with industry experts, should be a minimum of 0.15 kW/1000 gallons holdup. In cases where the SERI 1991 report indicated lower mixing requirements, requirements were increased to reflect the newer minimum mixing power.

(l) Wood Handling and Pumping

Centrifugal pumps are not appropriate for this type of service. Positive displacement pumps, normally screw-type, are the best devices for this type of service; they can handle sticky slurries without compacting the material.

The pumps used in wood slurry applications will be lobe pumps.

For slurry pumps, an Brake Horsepower (BHP) efficiency of 75 percent was used; this value is conservative and actual pump efficiencies may be higher. For other liquid pumps, an 85 percent efficiency was assumed; this is consistent with conventional centrifugal pump design.

C. PROCESS DESCRIPTIONS: INSIDE BATTERY LIMITS (ISBL)

A description of a Chem Systems' process design for a nominal 50 million gallon per year ethanol plant is presented below. The corresponding equipment list is given in Appendix V. The process flow diagrams are presented in Section IV. Simplified block flow diagrams are presented in this section.

1. Feedstock Composition Basis

The feedstock composition basis has been revised from the 1991 SERI report to account for hemicellulose concentrations found in poplar and other similar woods.

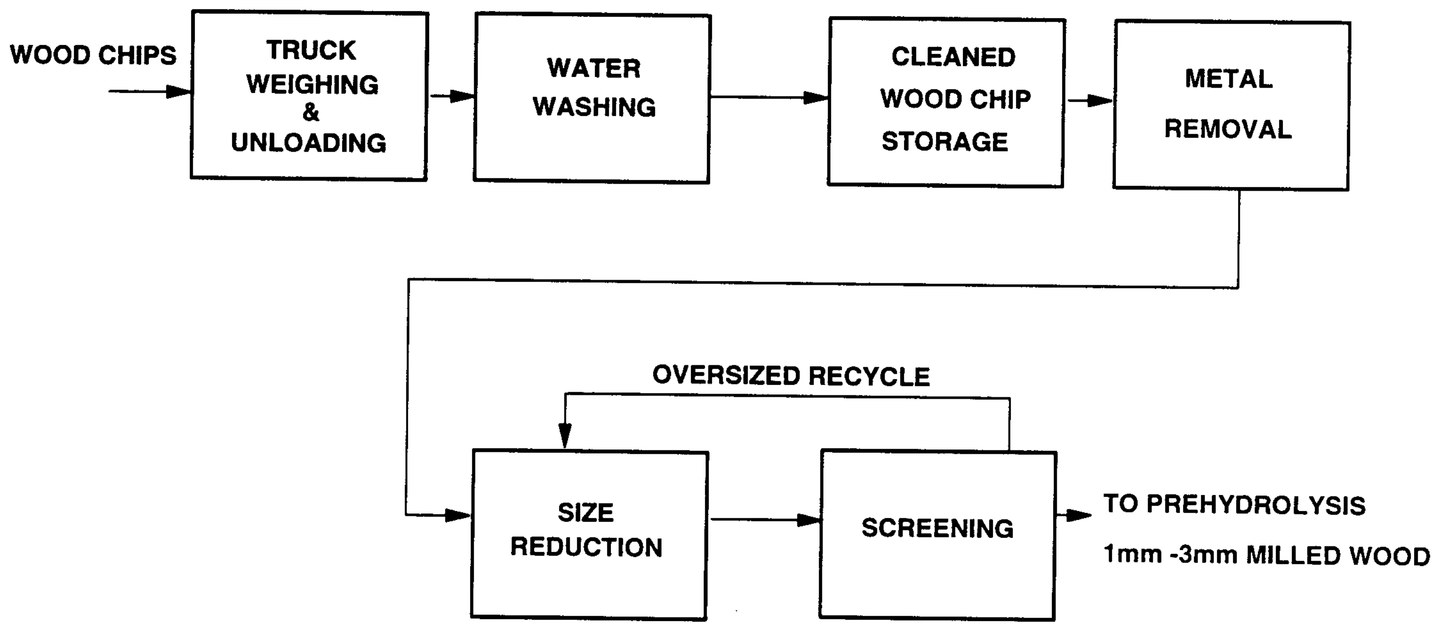
Cellulose:	46.20 wt%
Xylan:	18.05 wt%
Arabinan:	1.35 wt%
Galactan:	1.04 wt%
Mannan:	3.56 wt%
Lignin:	24.00 wt%
Soluble solids:	5.60 wt%
Ash:	0.20 wt%

2. Wood Handling

A block flow diagram of the wood handling area is shown in Figure III.C.1. Freshly cut 1.0-in wood chips are delivered by 23-ton trucks to a receiving station, which consist of a hydraulic truck dumper with scale (GY-101A/B/C/D). Chips are off-loaded into a storage pile. Wood from the pile is off-loaded by front-end loaders (GM-101A/B/S) into a washing flume, where heavy tramp materials are separated from the chips. The wet chips are swept by water flow via a flume pump (PP-101) to be picked up by a radical stacking conveyor (GS-101), which transfers the chips to the disk refiner (GG-101A/B/C/D). Along the conveyor, small magnetic items of down to 12.7 mm are removed by a magnetic chip cleaner (GS-103). The chips are milled down to 3 mm. The milled chips drop directly onto the milled chip belt conveyor (GS-102) and are delivered to the screw feeders (GS-202A/B).

Milling power is estimated at 95 kWh per dry ton.

FIGURE III.C.1
BLOCK FLOW DIAGRAM
SECTION 100 - WOOD HANDLING



3. Prehydrolysis

The slurry screw feeders (65-202/t/b) delivers slurry to the impregnator reactor (MR-201). The plug screw feeder is connected to a tee-pipe assembly which discharges directly to the inlet of the chemical mixer. The tee-pipe assembly is equipped with a shredder down screw to break-up the material plug prior to impregnation with sulfuric acid solution. The impregnated material is discharged directly into the first horizontal hydrolyzer. Two horizontal hydrolyzers are connected in series to provide 10 minutes retention time based on 70-80 percent fill rate. The horizontal hydrolyzer (digesters) are equipped with steam inlet connections for the medium pressure saturated steam required to complete the reaction. The cut flight and paddle type screw design will provide the proper agitation of the impregnated cellulosic material to allow the saturated steam to penetrate to the center which is necessary to achieve a uniform cook. The digested material is discharged from the second horizontal hydrolyzer via a vertical discharger arrangement. The prehydrolysis and neutralization areas are shown in Figure III.C.2

The following reactions take place:

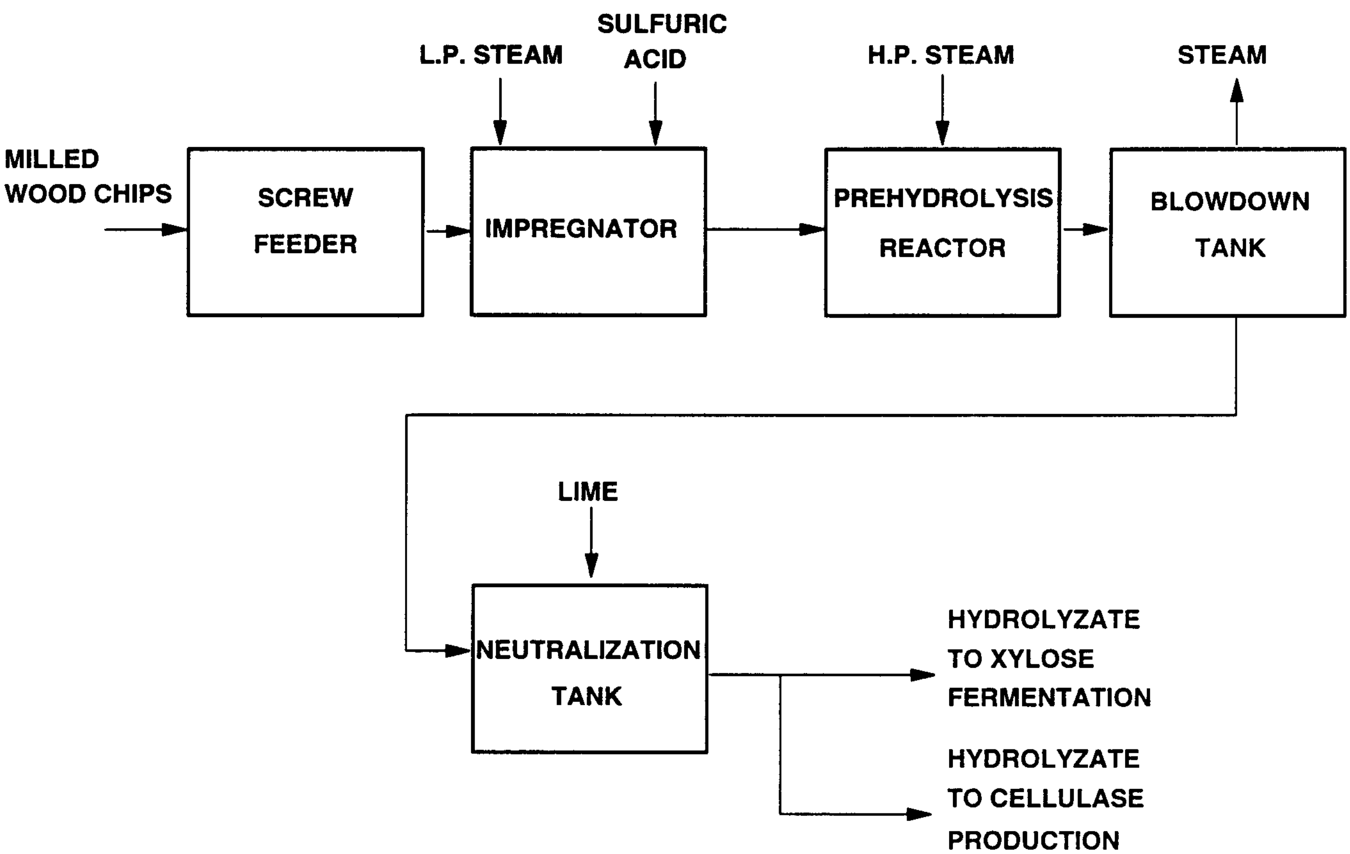
Cellulose to glucose:	3 percent conversion
Mannan to mannose:	80 percent conversion
Galactan to galactose:	80 percent conversion
Cellulose, mannan and galactan to HMF:	0.1 percent conversion
Xylan to xylose:	80 percent conversion
Arabinan to arabinose:	80 percent conversion
Xylan and arabinan to furfural:	13 percent conversion

The remaining cellulose, hemicelluloses and solids remain unconverted. The hemicellulosic components are assumed bound with xylan, and thus to hydrolyze at similar rates to xylan.

The vertical discharger from MR-201 is designed specifically for discharging from medium pressure-type application in combination with two shutter-type blower valves. The digested pulp is then blown into the blowdown tank (T-203), which operates at 108 kPa.

The prehydrolyzate undergoes an adiabatic flash to cool the material; the vapors are used for heat recovery to preheat the fermented mash going to the beer still (see Area 600).

FIGURE III.C.2
BLOCK FLOW DIAGRAM
SECTION 200 - PREHYDROLYSIS AND NETURALIZATION



In the lower section of the blowdown tank, the flashed slurry is mixed with hot recycle water to dilute the solids concentration to 12.0 weight percent. Residence time is negligible (set at 5 minutes), and mixing power is set at 1.5 kW/1000 gallons.

The slurry is then pumped by the hydrolyzate pump (PP-202) to hydrolyzate neutralization.

4. Neutralization

Hydrated lime ($Ca(OH)_2$) is delivered from the lime hopper rail cars to a slurry storage tank (T-730), where it is mixed with fresh makeup water (PP-731) to form a 50/50 slurry of $Ca(OH)_2$ and water. Lime from the slurry storage tank is then sent to fill the lime slurry day tank (T-220) via pump PP-732. The slurry is then metered via the slurry pump (PP-221) to the neutralization tank (T-206). Mixing power is specified at 1.5 kW/1000 gallons. It is presently assumed 1 mole of $Ca(OH)_2$ can fully neutralize one mole of sulfuric acid. Due to solids present in the system, and imperfect mixing, the actual lime consumption may be higher for full neutralization. In future studies, actual neutralization potential of lime will need to be evaluated in the presence of the solids to calculate actual as opposed to theoretical lime consumption.

The neutralizate is then cooled to 37°C using a cooling tower water heat exchanger (TT-220). The hydrolyzate pump (PP-203) then distributes hydrolyzate to xylose fermentation and cellulase production.

The split of hydrolyzate between cellulase production and xylose fermentation is determined by a balance of cellulase consumed during SSF vs. cellulase production. The following formula defines the flow split:

$$XLm_c = (1-X)(m_c + m_x)Y$$

where:

X = fraction of stream to SSF
L = cellulase loading in SSF, IU/g cellulose
m_c = cellulose flow rate, kg/h
m_x = xylose flow rate, kg/h
Y = cellulase yield, IU/g cellulose

Under the base case conditions, X is approximately 3 percent of the hydrolyzate. IU is an International Unit which describes enzymatic activity. IU to grams is dependent on the specific enzyme and generation.

5. Xylose Fermentation

The hydrolyzate not sent to cellulase production is pumped to the xylose seed fermentation area. Here it is split into streams going to xylose fermentation and xylose seed fermentation. Refer to Figure III.C.3.

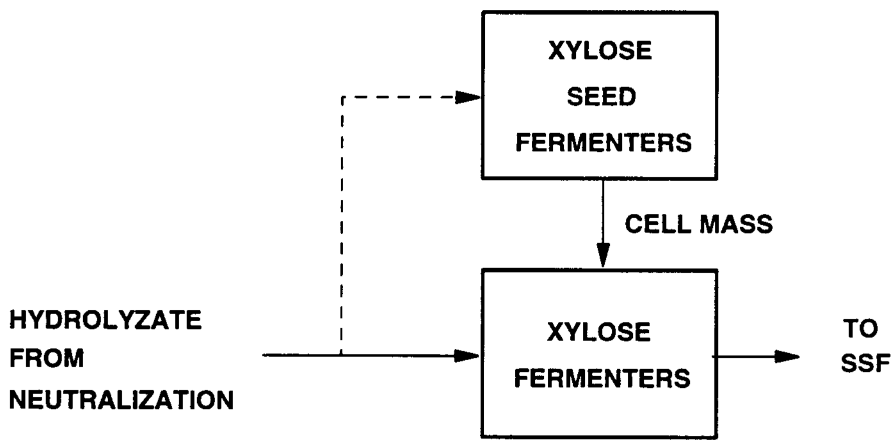
Anaerobic xylose fermentation occurs in a series of 750,000 gallon stirred tank reactors (FM-303A/F). Fresh inoculum (10 vol percent) and the wood slurry are mixed into the first fermenter. Flow between successive fermenters is via hydraulic head; each fermenter is approximately 18 inches higher than the next one in line. The fermenters operate at 108 kPa, and at 95 percent capacity. The process is controlled to operate at 37°C, using internal cooling coils cooled by chilled water rising from 10°C to 13°C, and a pH of 6.5, using bubbled ammonia as the neutralizing agent. Ammonia consumption for neutralization is estimated at 0.0296 kg ammonia per kg ethanol produced (no data was available on acid production during fermentation). Total fermenter residence time is set at two days.

The ethanol conversion is set at 85.5 percent: only 90 percent of the total sugars (pentoses and hexoses) are available as free sugars for fermentation (the remaining are unavailable as sugar bound to wood solids), and the theoretical conversion of free sugars to ethanol is 95 percent. Cellmass growth is assumed to be negligible under xylose fermentation conditions.

Mixing power for the fermenters is set at 0.15 kW/1000 gallons. (See discussion in Section III).

E. coli inoculum is grown in a series of six seed batch fermenters, filled to 95 percent of their capacity on a combined 2.0 weight percent glucose/xylose substrate. The fermentation time is 12 h/batch fermenter with an additional 12 hours for cleaning and turnaround. The temperature is maintained at 37°C using internal cooling coils supplied by chilled water, and there is no pH control.

FIGURE III.C.3
BLOCK FLOW DIAGRAM
SECTION 300 - XYLCSE FERMENTATION



Unlike the 1991 SERI report, CO_2 production from cellmass growth has not been ignored. Fermentation gases are sent to the boiler for incineration. Air injection is set at 0.2 vessel volumes per minute (vvm). Mixing power is set at the minimum, 0.15 kW/1000 gallons. Cooling of heat of fermentation is supplied by chilled water running through internal cooling coils.

The contents of the seed fermenters flows via pressure difference (due to fermentation air compressors) continuously to the first xylose fermentation tank, from a seed hold tank (T-301). The mixing power is also set at 0.15 kW/1000 gallons.

It is assumed that cellulose, xylan, arabinan, galactan nor mannan are consumed during the seed fermentation process. Ammonia is added as a nitrogen source for cell growth. Ammonia consumption is assumed to be stoichiometric, or 0.169 kg NH_3 per kg cellmass grown. Cellmass is assumed to have the following empirical composition, based on 50 percent by weight protein: $CH_{1.640}N_{0.230}O_{0.390}S_{0.004}$. Sulfur was ignored due to the small percentage in the empirical formula. Cell growth yield is estimated at 0.5g cellmass per g substrate consumed.

Offgases from the seed fermentation are sent to the LP vent system for incineration. Offgases from the xylose fermentation are sent to the vent scrubber for ethanol recovery.

Fermented product is sent to SSF via a booster pump (PP-303).

Process simulations which calculate material and energy balances require conversion and selectivity to calculate balances. Conversion is defined as:

$$1 - \frac{\text{(mol reactant remaining)}}{\text{(mol reactant at start)}}$$

Selectivity is defined as:

$$\frac{\text{mol desired product}}{\text{mol all product}}$$

Yields define reactions in terms of products, not the reactant;

$$Y = \frac{\text{mol reactant used}}{\text{mol desired product}}$$

Yields do not account for any byproduct formation; some of the reactant used may have been used for byproduct formation. Therefore, yield data is insufficient to provide enough data for a reaction data in terms of yields. Only in the 1991 SERI report material balance are overall conversion provided indirectly. As such, the model simulation uses these fixed conversions, not conversions based on the reactor conditions (temperature, pressure, residence time, etc.). The model cannot at the present time estimate conversion changes due to changes in reaction conditions. Future pilot data will need to be provided in terms of sugar/hemicellulose conversions and ethanol selectivity in order to allow the model to estimate changes in conversions based on changing fermentation conditions.

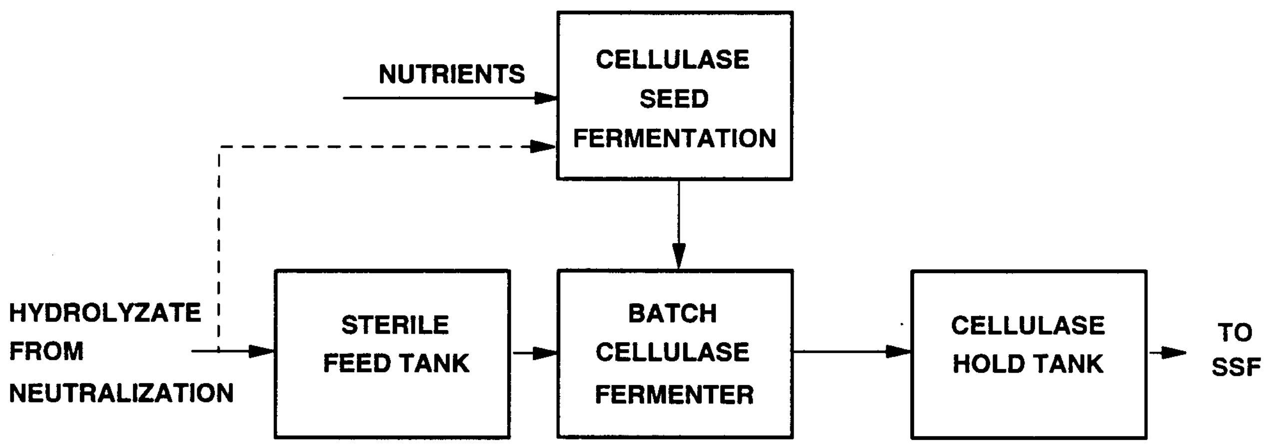
6. Cellulase Production

Neutralized hydrolyzate is split into two streams: one for cellulase seed fermentation, the other for cellulase production. A block flow diagram of the cellulose production area is shown in Figure III.C.4.

T. reesei inoculum is aerobically obtained from a series of batch cellulase seed fermenters (FM-401/2/3/4 A/B). Each is filled to 80 percent capacity, and flow is via pressure difference supplied by fermentation air pressure. Each seed fermenter has a batch cycle time of 4 days (residence time 3.5 days). The inoculum for all seed fermenters is 5 vol percent. For the last seed fermenter, the initial substrate composition is 1 weight percent combined cellulose/xylose; for the remaining fermenters, 1.0 weight percent glucose is used.

Cooled recycle water is used for dilution (cooled via CWS in TT-301A). The seed fermenters are maintained at 28°C via internal cooling coils, supplied by chilled water with a temperature rise of 3°C. Fermentation air is supplied at a rate of 0.2 vvm. Mixing power is supplied at 0.37 kW/1000 gallons holdup for the final fermenter, and 1.5 kW/1000 gallons for the remaining fermenters. Ammonia is used to maintain pH at 4.8.

FIGURE III.C.4
BLOCK FLOW DIAGRAM
SECTION 400 - CELLULASE PRODUCTION



It is assumed that *T. reesei* and *E. coli* have similar empirical cell compositions. As per design data, xylan and arabinan are not consumed as substrate during cellulase seed fermentation or production. No cellulase is assumed to be produced in the seed fermenters.

Feed is delivered to the aerobic cellulase batch fermenters (FM-401A/B/C) from the cellulase feed hold tank (T-405 and PP-401), with five percent inoculum as well. Each tank is a batch fermenter of 250,000 gallons, running at 80 percent capacity with a cycle time of two days each for a total batch time of 5.7 days, and a cycle time of 6 days. Corn steep liquor and nutrients are sterilized at 121°C for five minutes in the media prep tank (T-400) by external steam heating, and the delivered to the cellulase fermenter via pump PP-411.

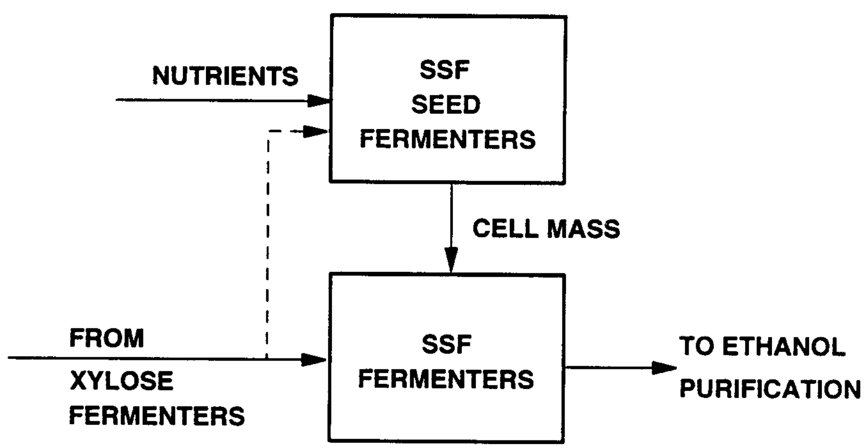
The cellulase production runs at 28°C. Recycle water is chilled to 28°C and added to the fermenter, producing a final cellulase concentration of five weight percent. The pH is maintained at 4.8, and the pressure is kept at 170 kPa.

7. Simultaneous Saccharification and Fermentation (SSF)

Material from xylose fermentation is split into two streams: 20 percent to SSF seed fermentation, and the remaining 80 percent to SSF. A block flow diagram of the SSF area is shown in Figure III.C.5.

Yeast inoculums of *S. cerevisiae* are grown in a series of batch seed fermenters (FM-501A/B to FM-506A/B) in two parallel aerobic tracks. The fermenters are operated at 95 percent capacity, with a total residence time of one day for *S. cerevisiae*. The inoculum for each train is 10 vol percent. The substrate used for each fermenter is 1.0 weight percent glucose, purchased, except for the final seed fermenter which uses xylose fermentation mash upgraded to 1.0 weight percent glucose. Cellulase loading is seven IU/g cellulose. The seed fermentation is controlled at 37°C via internal cooling coils fed by chilled water, and the pH is uncontrolled. Air flow rate is set at 0.2 vvm, while mixing power is specified at 0.38 kW/1000 gallons holdup for the final fermenter, 0.75 kW for the remaining seed fermenters.

FIGURE III.C.5
BLOCK FLOW DIAGRAM
SECTION 500 - SIMULTANEOUS SACCHARIFICATION AND FERMENTATION (SSF)



Cellmass production is estimated at 100 percent conversion of sugars, for 0.5g cellmass per g sugar. The vent gases are sent to the vent scrubber for ethanol recovery, since CO_2 production during cellmass growth results in ethanol lost in the vents.

The main portion of the xylose fermenter mash is mixed with the cellulase from the cellulase hold tank (T-410A/B) in the first SSF fermenter (FM-500A). Cellulase loading is specified at seven IU/g cellulose. *S. cerevisiae* inoculum, at 10 vol percent, are also blended into the first SSF fermenter. The SSF reactor consists of 750,000 gallon tanks, anaerobic continuous stirred tank reactors, arranged in parallel trains to yield a total residence time of seven days. Tanks are maintained at 95 percent capacity. Flow between the fermenters is by gravity flow. The temperature is maintained by internal cooling coils, supplied by chilled water raised from 10°C to 13°C. Mixing power is specified at 0.075 kW per 1000 gallons of holdup.

The SSF conversions are calculated to be as follows:

Hydrolysis	
cellulose to glucose:	87 percent
Mannan to mannose:	80 percent
Galactan to galactose:	80 percent
Xylan to xylose:	80 percent
Arabinan to arabinose:	80 percent
Fermentation	
Hexoses to ethanol:	87 percent
Hexoses to fusel oils:	0.1 percent
Hexoses to glycerol and acetaldehyde:	5.6 percent
Hexoses to cellmass:	7.3 percent

The pentoses are not consumed by the SSF fermentation yeasts. Cellmass yield is estimated at 0.5g cellmass per g hexose.

Vent gases comprised of CO_2 and entrained ethanol are sent to the vent scrubber for ethanol recovery. The SSF fermented mash is sent to ethanol purification via the SSF transfer pump (PP-505).

8. Distillation and Recovery

All ethanol-containing vents are directed to the vent scrubber (AS-604). The vent scrubber is a simple packed bed tower where vent vapors are directly contacted with cold process water to condense, absorb and recover ethanol from a dilute vent stream. The scrubber water rate is specified to achieve 95 percent ethanol recovery from the vent. The non-condensible vent gases are sent to the boiler for incineration. The scrubber bottoms are sent to the beer still (AS-601) via a transfer pump (PP-641) for ethanol recovery; the bottoms contain approximately one weight percent ethanol. A block flow diagram of the distillation area is shown in Figure III.C.6

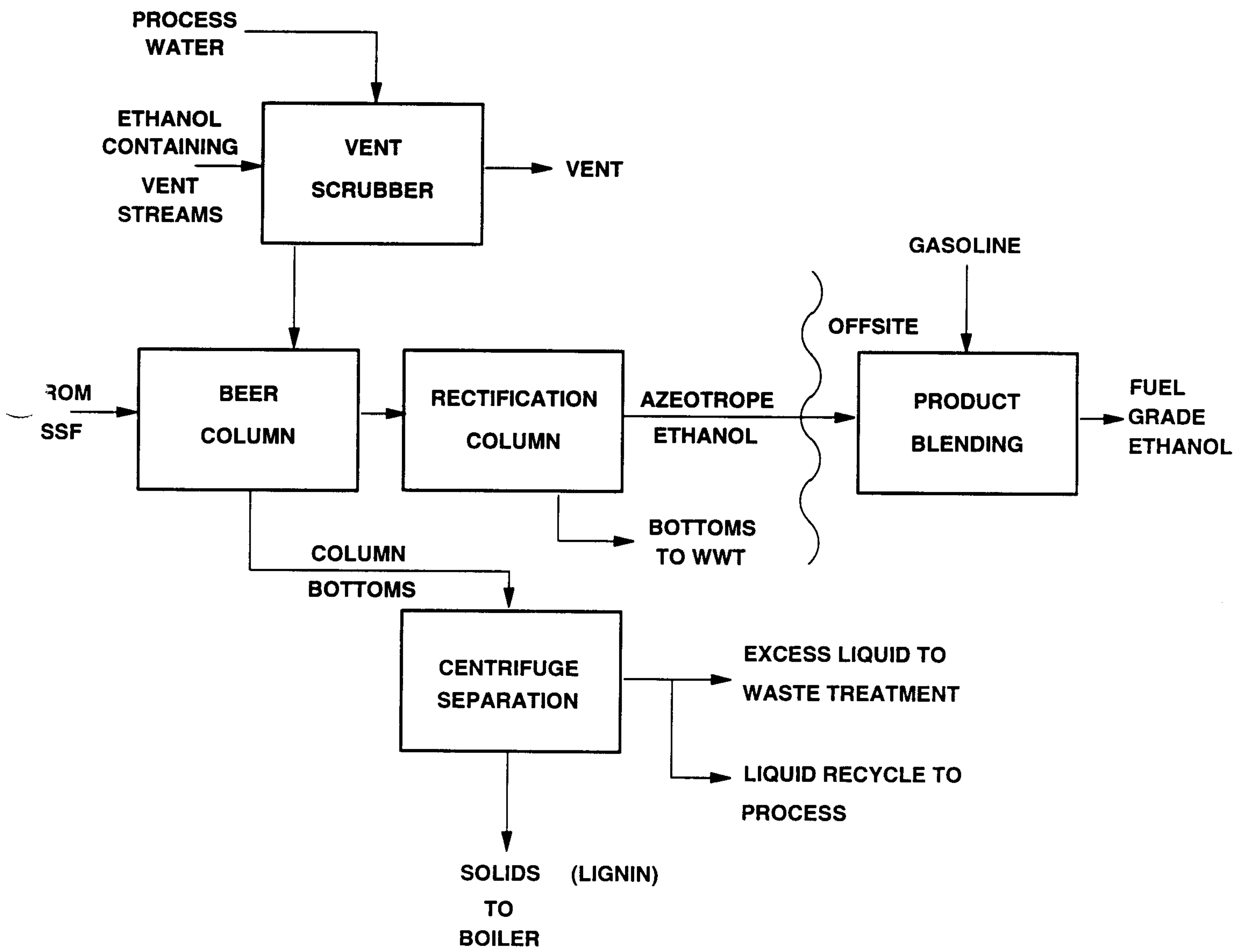
Fermenter mash from SSF is preheated in several steps by heat integration. The mash is first used to condense overheads from the rectifying column (AS-602), which heats the mash to 79°C in exchanger TT-623. The mash is then further heated by condensing the flash vapor from prehydrolysis in exchanger TT-615. This raises the mash to approximately 97°C. The mash is then passed through a degasser drum (T-601) to remove any dissolved gases and stabilize operation of the beer still. Any flashed gases are sent to the scrubber to recover entrained ethanol.

The degasser drum bottoms are then further heated using the bottoms of the beer still (TT-629), up to 120°C. A trim heater using HP steam (TT-613) is supplied for start-up and upset conditions, but is not expected to be used during normal operation.

The ethanol-rich water from the scrubber (AS-604) is preheated using the hot condensate from the flash exchanger (TT-615), and further heated to 120°C using the bottoms of the beer still in exchanger TT-625.

The beer still is a 38 (actual) tray column operating at 412 kPa which preconcentrates the beer mash to approximately 66 weight percent ethanol in water, which leaves overhead, along with light impurities such as methanol, acetaldehyde, and other contaminants (e.g. fusel oils). The reflux ratio is set at 2. The bottoms of the beer still comprise the remaining water, solids, and heavy contaminants (e.g. glycerol). The bottoms have been specified to contain no more than 100 ppm ethanol.

FIGURE III.C.6
BLOCK FLOW DIAGRAM
SECTION 600 - ETHANOL
PURIFICATION AND SOLIDS SEPARATION



The bottoms are used to preheat first the scrubber column waters (TT-625), then the main feed to the beer still, (TT-629). The bottoms, now at about 124°C, are further cooled to 113°C (TT-628) in order to prepare the flow for lignin separation.

The overhead vapor from the beer still is used to reboil the bottoms of the rectification still via TT-622. The reboiler does not consume the entire duty of the overheads, hence a trim cooler (TT-624) is also supplied for startups and trim conditions. The condensed overhead product is then sent to the rectification still.

5.2%?

The rectification still (AS-602) purifies the 66 percent ethanol to near azeotropic concentration; the overheads are 94.7 percent ethanol by weight, 53 percent water and the remaining 0.1 percent impurities. The column operates at 105 kPa, with 68 (actual) trays and a reflux ratio of 4. The overhead product is sent to ethanol storage prior to gasoline blending. The bottom product, specified at less than 100 ppm ethanol, is sent to wastewater treatment. The column also has a purge stream, set at 2 percent of the vapor leaving the top tray. This purge, which is sent to the boiler as waste fuel, is to prevent the buildup of acetaldehyde and other light impurities present as fermentation byproducts.

Fusel oils, which are a complex mixture of isoamyl, amyl, and branched four and five carbon alcohols, collect in the rectification still. They show a tight solubility profile, and typically form a separate phase somewhere between trays 15 and 20 of the rectification still. This separate fusel oils phase is decanted off the column to prevent buildup and subsequent carryover into the ethanol overheads. The fusel oils are first cooled with cooling tower water (TT-607) then sent to the fusel oil washer (T-603). The fusel oils are washed with 5 kg water per kg fusel oils to recover any entrained ethanol. The light phase fusel oils are then decanted off to the boiler for use as recovered fuel via the fusel oils pump (PP-605). The water phase is returned to the rectification still for ethanol recovery via the washwater return pump (PP-604).

The beer still bottoms are combined with sump solids from the recycle water tank (T-630) and sent to the lignin centrifuge (GC-609A/B/C). The centrifuge recovers 95 percent of the solids, and produces a 40 weight percent slurry. The concentrated solids are screw conveyed (GS-611) to the boiler (HB-901), where they are used as the main fuel source for the plant. Waster overflow from the centrifuge is sent to the recycle water tank (T-630), where it is mixed with fresh process water to cool the recycle water and provide makeup. The recycle water is then split off: 50 percent to wastewater treatment, and the remaining 50 percent recycled back to prehydrolysis, xylose seed fermentation, cellulase seed fermentation and SSF seed fermentation. It is assumed recycle water contains adequate nutrient load for cellmass growth in the seed fermentation areas.

D. PROCESS DESCRIPTION: OUTSIDE BATTERY LIMITS (OSBL)

1. Tank Farm: Area 800

Ethanol from the bottom of the stripping still (AS-603) is sent for storage to the ethanol product tanks (T-701A/B). These tanks have storage capability of 10 days production. Prior to storage, the ethanol is in-line blended with five percent gasoline by weight via blending pump (PP-710). Gasoline is delivered by truck or railcar to tankage (T-710), sized for 10 days storage. Denatured ethanol fuel is pumped to point of sale by the ethanol product export pump, (PP-701).

Corn steep liquor, used as feed for cellulase production, is delivered to the corn steep liquor storage tank (T-720) from truck or railcar. Storage capability is set at 30 days. The transfer pump (PP-720) delivers corn steep liquor from the storage tank to the media preparation tank (T-400).

Concentrated sulfuric acid (typically 93 percent) is delivered by railcar or truck to the sulfuric acid storage tank (T-703), where a nine day supply is kept. The tank is kept under positive pressure from dry process air to keep moisture from the outside air out. The sulfuric acid transfer pump (PP-703) delivers sulfuric acid to the sulfuric acid day tank (T-201).

Liquid ammonia is supplied by railcar or truck to the liquid ammonia storage tank (T-706), where four days supply is kept. Liquids ammonia is then supplied to the ammonia day tank (T-321) via the ammonia transfer pump (PP-706) as needed.

Corn oil, the antifoam agent used during cellulase production and SSF, is delivered by railcar or truck to the corn oil storage tank (T-707), sized for 21 days storage. Antifoam is pumped via the antifoam delivery pump (PP-707) to the antifoam tank (T-403).

Diesel fuel for the mobile equipment is delivered by truck and stored in the diesel fuel tank (T-708). The tank is sized for 14 days storage. Fuel is delivered to the mobile equipment via the fuel pump (PP-708).

Fire water is supplied by the process water system, and stored in the fire water tank (T-704). The fire water system is pressurized by the fire water pump (PP-704).

2. Wastewater Treatment: Area 800

The wastewater treatment area consists of anaerobic digestion, which accomplishes the majority of organic wastewater contaminant destruction, and an aerobic treater which polishes the remaining wastewater for utility water recycle.

Wastewater from the lignin separator (PP-631), the Clean-in-Place operations, and the still feed preheater (TT-615) are sent to the equalization tank (T-803). The anaerobic digester feed pump (PP-808) sends hot wastewater through a cooler (TT-802), lowering the temperature to 35°C, before sending it to the anaerobic digester (T-804). The offgases, mostly methane and carbon dioxide, are sent through a capture/condensation system to knock out entrained liquids and solids. The gases are then sent to the ~~boiler~~ for use as auxiliary fuel. The digester converts 90 percent of all the organics present, except ~~for lignin~~, for a biogas yield of 0.8 kg biogas per kg organics. The remaining 0.2 kg is used for cellmass growth. Biogas is 70 percent methane, 30 percent carbon dioxide. Processed wastewater from ~~the digester is sent to a~~ surge drum (MS-805) and pumped via the recycle pump (PP-809) to the aerobic biotreater (T-807). A portion is recycled back to the anaerobic digester.

Not the case in full report

The aerobic biotreater removes the remaining Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) from the wastewater. Combined with mother liquor from the sludge centrifuge (GC-801), the wastewater from the anaerobic digester is fed to the aerobic biotreater (T-807). Oxygen from a PSA ~~unit is fed via aerators (GV-807).~~ Oxygen feed is set at 1.5 times ThOD (Theoretical Oxygen Demand). The tank is open-air; no vent gases are captured. All organics except lignin are considered to be fully consumed, with no cellmass growth. Liquids from the aerobic biotreater are mixed with overflow from the sand filter backwash and boiler blowdown and fed to the secondary clarifier (GV-808). Overflow from the clarifier is sent to the process water tank (T-901) via pump PP-816 for storage prior to recycle.

Why?

Clarifier sludge is pumped (PP-813) to the sludge centrifuge (GC-801). Mother liquors from the centrifuge are recycled to the aerobic biotreater, while concentrated sludge is screw-fed (GS-801) to the boiler for use as fuel. The centrifuge is estimated to concentrate the sludge to 40 percent, with 95 percent recovery of the solids.

Soluble solids composition has been estimated to be $CH_{1.48}O_{0.19}$.

3. Utilities: Area 900

(a) Co-Generation System

The plant is designed with a boiler/power co-generation system which allows for the co-production of steam and electricity using a high pressure steam turbine. The system consist of a fluidized bed boiler for waste stream combustion and high-pressure steam generation, a dryer/baghouse unit to reduce the moisture content of the waste streams and remove particulate matter from the flue gas, a turbogenerator with steam extraction, a turbine exhaust steam condenser, a boiler feedwater preparation system and a make-up water treatment system.

Light organics which may be present in the waste stream from the dryer may require a scrubber to strip these components from the ~~g~~flue gas. It has been assumed that for this study that these elements are not present and the scrubber has not been included in the design.

Electrostatic precipitators (ESP) were considered for removing the particulate matter from the flue gas based on their proven technology (used in approximately one-third of the wood-burning power generators in the U.S.) along with cyclones, bag filters and wet scrubbing. However, since none of the proven methods for removing particulate matter are perfect and at NREL's request, we have used bag-filters as the basis.

The 10,300 kPa (1,500 psig) steam boiler is designed to burn gaseous and solid fuels (in slurry form) derived from the various organic waste streams in the process. The fuel compositions are shown in Table III.D.1. Lignin account for a majority of the energy in the fuel streams fed to the boiler. Other components that provide a significant portion of the energy are cellulose, soluble solids, cell mass and ethanol.

Gaseous fuels are fed directly to the boiler burners, but wet solids are first sent to a drying system that dries and fluidizes the solids into the boiler using boiler flue gas.

The steam and power generation capacities are sized in accordance with the wood fed rate. The steam turbine is an extracting type which allows for extraction of 50 and 150 psig steam to meet internal process requirements with the balance condensed to maximized the turbine output.

TABLE III.D.1
FUEL COMPOSITION
(kg/Hr)

Component	Liquid (Slurry)	Vapor
Cellulose	3,289	-
Xylan	175	-
Arabinan	13	-
Mannan	93	-
Galactan	27	-
Glucose	-	-
Xylose	92	-
Arabinose	7	-
Mannose	-	-
Galactose	-	-
Ethanol	2	450
HMF	-	2
Furfural	766	48
Glycerol	332	-
Lignin	17,406	-
Soluble solids	4,012	-
Cellmass	2,603	-
Cellulase	-	-
Acetaldehyde	1	6
Fusel oils	-	15
Methane	-	1,423
Inerts	25,476(1)	88,476(2)

(1) Water, gypsum and ash
(2) Water, air and carbon dioxide

Based on a steam turbine feed rate of 225 metric tons (497 thousand pounds per hour) of 510°C (superheated) 10,300 kPa steam and extraction of 116 metric tons (256 thousand pounds per hour) of 1,034 kPa (150 psig) and 39 metric tons (87 thousand pounds per hour) of 345 kPa (50 psig) steam, 38.1 megawatts of power are generated. With total plant demand of 19.4 megawatts, this results in a 18.7 megawatts power surplus which can be sold. The complete steam balance is provided in the Appendix.

(b) Cooling Water

The cooling tower is sized to provide maximum peak cooling rates for the plant, plus a 20 percent design factor. The cooling tower (GT-912) provides cooling water at 30°C, with a maximum allowable temperature rise of 14°C. Pressure in the system is maintained at 515 kPa via the cooling water circuit pumps (PP-912A-F). Cooling tower blowdown containing dissolved salts and other contaminants is discharged to an evaporation pond.

Cooling tower losses are estimated at 4.3 percent total: 1.3 percent for evaporation, 0.3 percent for wind losses, and 2.7 percent for blowdown based on the 1991 SERI report.

(c) Chilled Water

The chilled water system is a single pass refrigeration system, using HCFC-131a (or ammonia) as the main coolant. The chilled water package (PK-950) supplies chilled water at 10°C, with a maximum allowable rise of 8°C. The package is sized for the required refrigeration duty, plus a 20 percent design factor.

(d) Plant and Instrument Air

Plant and instrument air are provided by the Process and Instrument Air Compressor (PC-910), which supplies the P&I system with 790 kPa air. The compressor receives air through a filtration system. The compressor charges the air receiver (MS-906), which sends air to the plant air receiver (MS-907) via the instrument air dryer (GY-910). The dryer is specified to supply air with a dew point of -80°C.

(e) Sterile Air

Sterile Air for fermentation is supplied by the sterile air package (PK-950A/B/C). The package supplies air based on requirements plus a 20 percent design factor. Air is cooled to 28°C by intercoolers (included, refrigeration duty supplied by chilled water) and sent through a filtration system prior to fermentation users.

(f) Process Water

Well water is pumped (PP-913) through a sand and anthracite filter (GF-901). Filtered water is then pumped (PP-902) to storage in the process water tank (T-901). Backwashing of the filter is accomplished using process water via backwash pump PP-904. Backwash is collected in the backwash transfer tank (T-905) before transport by pump (PP-905) to the secondary clarifier (GV-808). The process water main is supplied by the process water circulating pump (PP-903).

(g) Clean In Place and Chemical Sterilization System (CIP/CS)

The CIP/CS system is designed to clean and sterilize fermentation tanks between batches and other downtimes to minimize the need for manual cleaning.

Sterile tanks and fermenters are cleaned prior to use by hot water, which has been held for 15 minutes in the water sterilizer (TT-953) at 115°C using LP steam. The water is then held in the sterile water tank (T-953) prior to use. The sterile water pump (PP-953) feeds sterilized water to users on demand, rinsing the user prior to CS.

Cleaning chemicals are mixed with the sterilized water in the cleaning tank (T-961). The solution is pumped on demand using the CS pump (PP-960). Spent cleaning solution is returned to the cleaning tank via the CIP/CS sump pump (PP-965A/B/C/S), one for each user. The vessel is then rinsed a second time with sterile water; the water is sent to wastewater treatment. The process is repeated twice: rinse, CS, rinse, CS, rinse. Periodically the cleaning solution is dumped to wastewater treatment via the supply pump (PP-960).

No design data was available for the CIP/CS system; the sizing was arbitrarily set at 10,000 gallon hold tanks, for an average flow rate of 150 kg/h.

IV BASIS OF MODEL DESIGN

A. SIMULATION SYSTEM

Chem Systems modelled the biomass-to-ethanol process using CHEMCAD version 3.03-386, a continuous process simulator for PC computers from Chemstations Inc. of Houston, TX. CHEMCAD offers a multitude of unit operations, including solids handling capabilities, a wide array of thermodynamic options and a large component database with the ability to add user-defined components.

CHEMCAD also has a graphical interface to draw process flow diagrams. This has been used by Chem Systems to draw the process PFDs.

The utility generation units and the economic and capital and production cost estimates have been modelled in Lotus 1-2-3, and are described in Section V.

Physical property data for the solids, liquids and gases are shown in Appendix VI.

B. PROCESS MODEL

1. Model Architecture

The model has been split into four separate CHEMCAD simulations: "BASE-ALL", "ETOH-2", "BASE-ETH" and "BOILER". "BASE-ALL" simulates area 200, 300, 400, 500 part of 600, and 800. "BASE-ETH" simulates the scrubber of area 600. "ETOH-2" simulates the ethanol purification steps of area 600. "BOILER" simulates the recovered fuel feeds which will feed the boiler/co-generation unit (simulated on-line in the Lotus 1-2-3 model). "BASE-ETH" simulates the ethanol vent scrubber.

This artificial split was necessitated by the occurrence of many user-defined components in the system. Distillation operations are difficult to model, and the presence of user-defined components, as well as any other process configuration that encourages non-ideal separations, can slow down solutions or even prevent convergence. Since the user-defined components lacked any binary interaction parameters, they were not included in the ethanol purification modelling. This is a realistic solution, since the solids ultimately go out the bottom of the beer still and only affect the separation by mildly increasing the reboiler duty of the beer still. This has been accounted for by heating the separate solids stream and adding this duty to the beer still reboiler duty.

The software component database contained all the required binary interaction parameters for the main liquid components affected by the separation, using the NRTL (Non-Random, Two Liquid) liquid activity coefficient model. The only pair not adequately modelled using software data was acetaldehyde/ethanol; for this pair, literature data replaced software-supplied data (via UNIFAC estimates) to yield a more realistic result. See Appendix VI for physical property data.

At this time, the boiler feed streams have been separated; all were a recent addition to the model, and inclusion into the "BASE-ALL" model would have required extensive flowsheet modifications.

Although flowsheets are provided for each area, all flowsheets within a particular simulation model have been hot-linked, meaning any change in one is automatically picked up in others. This provides for overall solutions faster and more accurate as it avoids the need for manual importation of data from one flowsheet to the next.

2. Base Data

User-defined components were added to the CHEMCAD component library, in order to simulate the actual conditions of the biomass-to-ethanol plant. The following user-defined components were added to the component database:

- Cellulose
- Hemicelluloses:
  - Xylan
  - Arabinan
  - Mannan
  - Galactan
- Sugars:
  - Xylose
  - Arabinose
  - Mannose
  - Galactose
- HMF (Hydroxymethyl furfural)
- Ash
- Lignin
- Soluble Solids
- Cellmass
- Cellulase

Because CHEMCAD can only simulate 5 components as solids at any one time, additional user-defined components that were solids were modelled as extremely heavy liquids (T_c=10000°C, P_c=1,000,000 kPa) to simulate the properties of a solid. However, a nominal vapor pressure was still apparent for the user-defined solids; and therefore in many cases Component Separators (an ideal unit operation provided by CHEMCAD) were used to direct the components in the right direction.

Fusel oils are a by-product of sugar fermentation; they are a complex mixture of long-chain-hydrocarbon alcohols. Major components are isoamyl alcohol, amyl alcohol, and isomers of methyl and ethyl propanol. For the simulation, fusel oils were modelled as 3-methyl-1-butanol (isoamyl alcohol), which normally comprises at least 50 percent of fusel oils from poplar fermentation.

Appendix VI lists the physical property data for each of these components. CHEMCAD primarily uses data from the AICHE (American Institute of Chemical Engineering). DIPPR database, and the ACS (American Chemical Society) database. The following components from the CHEMCAD databank were used:

- Glucose
- Ethanol
- Furfural
- Glycerol
- Acetaldehyde
- 3-methyl-1-butanol (fusel oils)
- Air
- Nitrogen
- Oxygen
- Ammonia

3. Reactors

No data ~~was~~ were available on reaction kinetics, nor on reaction equilibria in terms of unit conversions. Process simulators cannot use yield data for process simulation, since such unit operations require reactant conversion to simulate reactions. Since only conversion data based on the 1991 SERI report mass balances was available, all reactions were modelled using stoichiometries in an equilibrium reactor, using a fixed conversion rate.

This method creates a model which is insensitive to changes in reactor conditions, a prime motive force for reaction kinetics. Any changes in residence time, temperature or catalytic or enzymatic activity must be manually evaluated for effects on reaction conversion rates, and the reactor conversion rates changed manually to account for these new conditions. Should NREL in the future wish to have a more robust model, pilot plant and other data will have to be converted into a kinetic function of temperature, pressure, residence time and concentrations for the simulator to dynamically account for reactor conditions in modelling the system.

4. Agitators

The heat of mixing has been simulated using an extremely low efficiency mechanical pump. Since the CHEMCAD version licensed by CSI does not have the capability to model agitators with respect to the heat of mixing, by using a liquid pump unit operation with an efficiency of 0.0001, pressure increases on the order of 1 kPa (<1 percent total pressure) are enough to add the required heat of mixing without increasing significantly the pressure of the stream.

C. AREA DESCRIPTIONS

The following section describes in detail the simulation for each of the flowsheets modelled. This description includes equipment modelled, the model architecture, missing equipment, and other pertinent data.

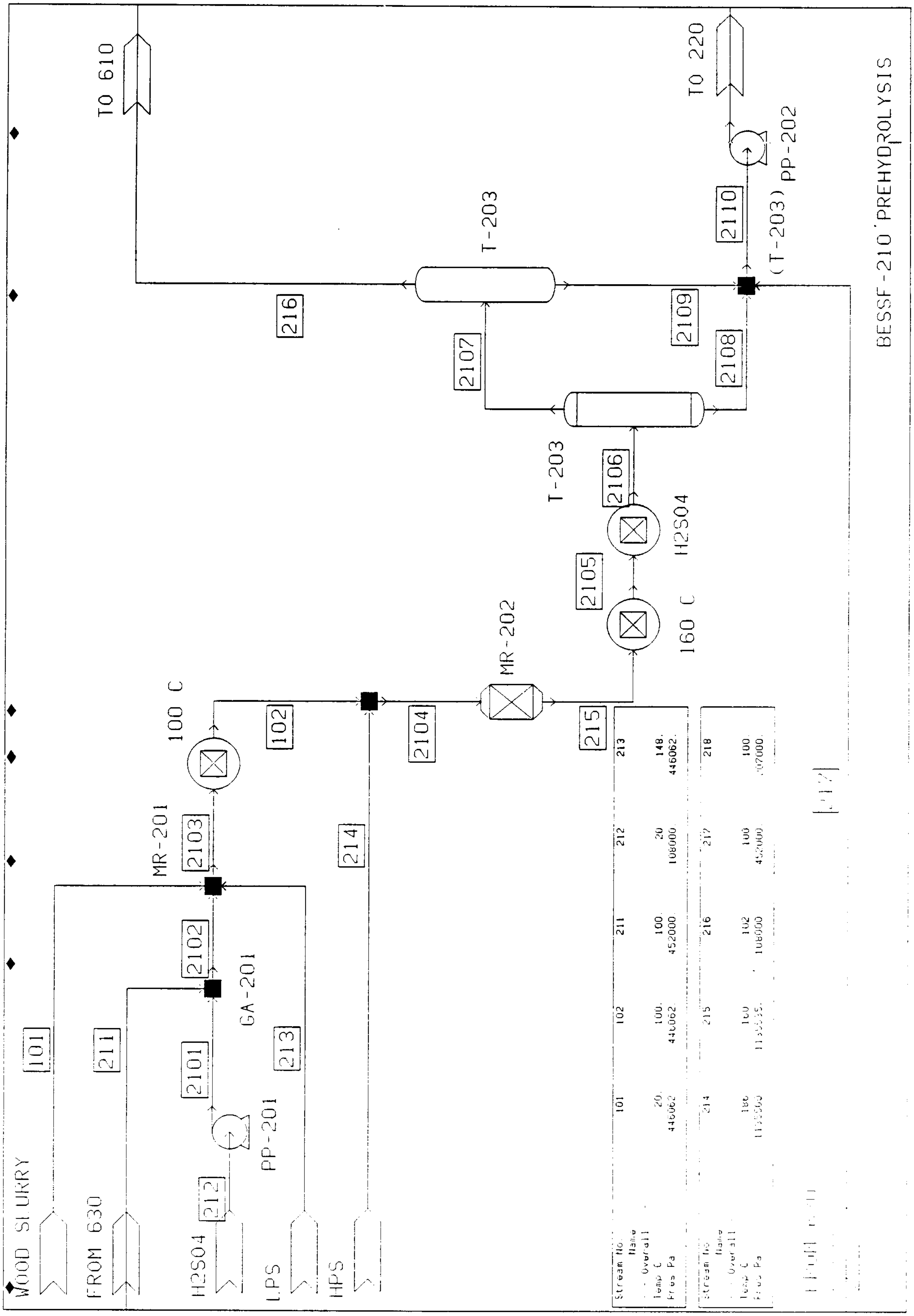
In all cases, to the extent possible, the current model has retained the same equipment names and numbers from the 1991 SERI report.

The stream numbers in the descriptions have been assigned based on in the following convention: in the case where a stream coincided with the 1991 SERI report flowsheet, the same stream number was used. Where new streams were added, they were given 4 digit numbers, with the first two digits the same as the first two digits of the flowsheet. I.e.: all streams on flowsheet BESSF-210 which were not in the 1991 SERI report are numbered 21XX.

In general, flowsheet numbers correspond to their respective process areas. The flowsheets keep the same convention as the 1991 SERI report; where a SERI flowsheet has been split into multiple flowsheets, suffices "A", "B", etc. have been added, (i.e. BESSF-310 A and B used to be one flowsheet in 1991 report; they are now two). Where new flowsheets appear, a new number has been assigned (i.e. BESSF-821 is a flowsheet that did not exist in the 1991 report). The heat and material balances for all the areas except the distribution section and steam generation can be found in Appendix I. The distillation area material balance is located in Appendix II and the steam balance in Appendix VII. Component balances for ethanol and water are presented in Appendix IV.

1. Area 100

Area 100 has not been simulated on CHEMCAD. The unit operations required in this area are not available on CHEMCAD at this time. The unit operations relate to wood handling, feed and size reductions which for vendor feedback is the most important criteria.



Stream No.	101	102	211	212	213
Name					
Overall					
Temp C	20.	100.	100.	20	148.
Pres Pa	446062	446062.	452000.	108000.	446062.

Stream No.	214	215	216	217	218
Name					
Overall					
Temp C	186	160	102	100	100.
Pres Pa	1135500	1135535.	108000	452000.	107000.

2. Area 200

Area 200 has been separated into two flowsheets:

BESSF-210: Prehydrolysis
BESSF-220: Hydrolyzate Neutralization

(a) *BESSF-210: Prehydrolysis*

Recycle water (211) from area 600 is mixed with sulfuric acid (pumped from a tank via PP-201) in mixer GA-201. PP-201 supplied enough head to raise the sulfuric acid to recycle water pressure. Recycle water addition has been manually controlled to provide a 35 weight percent biomass to the impregnator reactor.

Initial wood slurry composition (wet basis) was taken as the following:

Water:	50.00 wt%
Cellulose:	23.10 wt%
Xylan:	9.02 wt%
Arabinan:	0.68 wt%
Galactan:	0.52 wt%
Mannan:	1.78 wt%
Lignin:	12.00 wt%
Soluble Solids:	2.80 wt%
Ash:	0.10 wt%
	100 wt%

The dilute sulfuric acid (2102) is then mixed with wood slurry (101) and low pressure steam (213) in MR-201. MR-201 is modelled strictly as a mixer, since the wood hydrolysis reactions are assumed to take place only under the conditions of MR-202. Low pressure steam addition is controlled to raise stream (102) temperature to 100°C.

High pressure steam (214) is added to the impregnated wood, and the resultant mix is sent to MR-202 for hydrolysis simulation. The following reactions have been modelled adiabatically:

Cellulose hydrolysis (3 percent conversion)

$C_6H_{10}O_5 + H_2O \dashrightarrow C_6H_{12}O_6$

Cellulose (mannan, galactan) degradation (0.1 percent conversion)

$C_6H_{10}O_5 \dashrightarrow C_6H_6O_3 + 2\ H_2O$

Xylan (arabinan, mannan, galactan) hydrolysis (80 percent conversion)

$C_5H_8O_4 + H_2O \dashrightarrow C_5H_{10}O_5$

Xylan (arabinan) degradation (13 percent conversion)

$C_5H_8O_4 \dashrightarrow C_5H_4O_2 + 2\ H_2O$

Two controllers make sure the reactor operates at specification: one for steam addition to insure the flow of (214) is sufficient to keep the reactor outlet at 160°C, and the second to control sulfuric acid flow to 0.85 weight percent (0.156 mol percent) of reactor effluent water.

Two separators model the blowdown tank (T-203). The first is an adiabatic flash at 108 kPa. The second is a component separator to remove the solids, otherwise some of the user-defined solids appear in the vapor stream. The vapor stream is used for heat recovery as beer-still feed preheat (216). The flash bottoms are mixed with recycle water (stream 217) to cool and dilute the stream to 12 weight percent solids.

The recycle water is added after the flash; in reality, the recycle water is mixed in the bottom of the flash tank with the flash liquid. The flash has by that point ended, even though it is still the blowdown tank. Had the recycle water been added with the flash tank in the model, the result would have been a lower vapor flow since the recycle water would have first cooled the reactor products, then flashed the mixture second.

(b) BESSF-220: Hydrolyzate Neutralization

Hydrolyzate from the blowdown tank (stream 218) is mixed with lime. A controller regulates the amount of lime addition (a 50 percent $Ca(OH)_2$/50 percent water slurry from tank T-730) so that calcium hydroxide concentration is zero leaving the neutralizer. In the future, more accurate data regarding the actual lime neutralization potential will be needed to more accurately assess lime consumption.

The neutralization reaction is modelled in an equilibrium reactor (T-206), under adiabatic conditions, with the following reaction taking place:

Neutralization (100 percent conversion)
$H_2SO_4 + Ca(OH)_2 \dashrightarrow CaSO_4 + 2\ H_2O$

Gypsum, which is hydrated calcium sulfate ($CaSO_4 \cdot 2H_2O$) is not modelled by CHEMCAD. Solubilities are not part of the databank, and can only be used within the context of a crystallizer unit operation, not within streams, to determine how much of a particular solid is as solute or as precipitate. Solubilities will be manually simulated.

From this point downstream, gypsum is modelled strictly in terms of anhydrous calcium sulfate. Water, whether associated with the sulfate or not, is considered part of the water balance only.

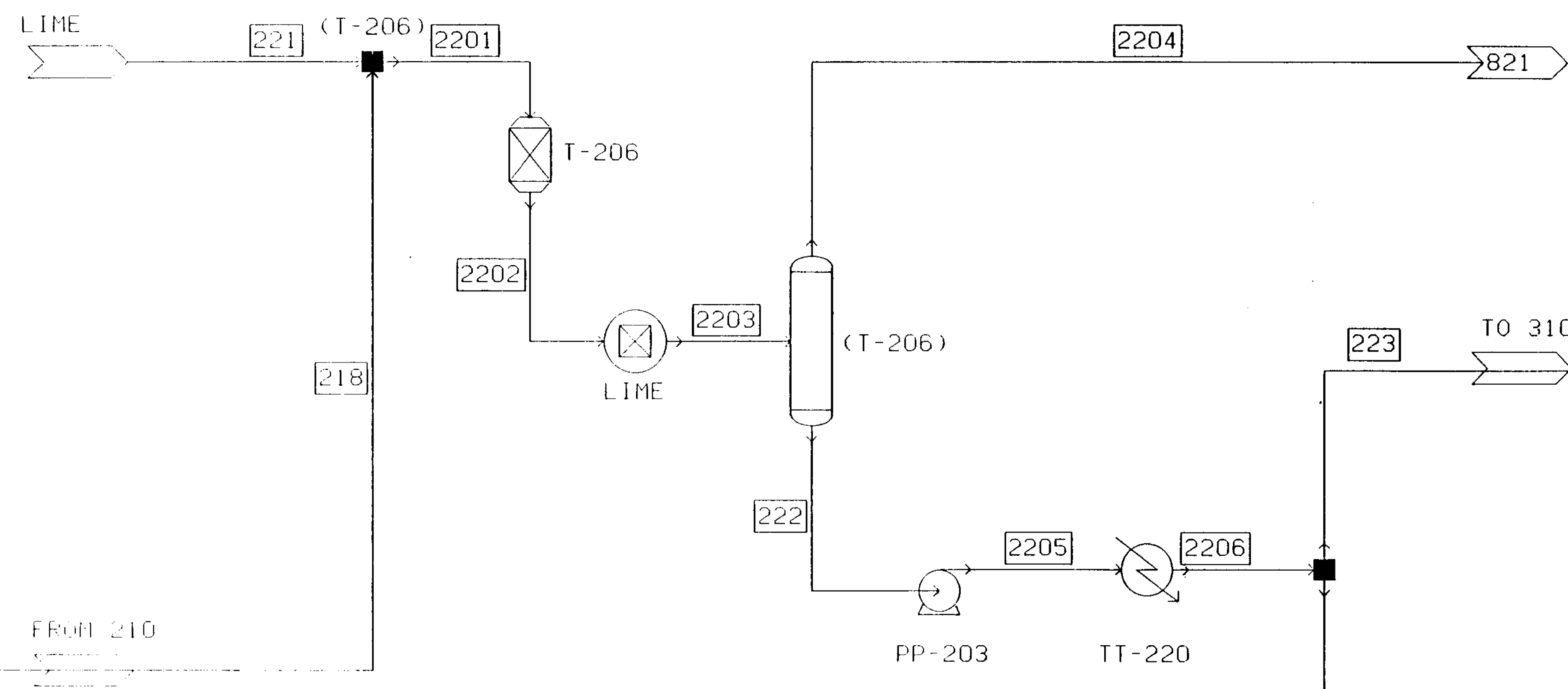
The neutralized hydrolyzate is pumped through a cooler (TT-220) to reduce the solution to the required fermentation temperature (37°C) and then split between xylose fermentation and cellulase production. The cooler duty has been increased by 26.8 kW to account for the heat of mixing at 1.5 kW/1,000 gal.

3. Area 300: Xylose Fermentation

(a) BESSF-310A: Xylose Seed Fermentation

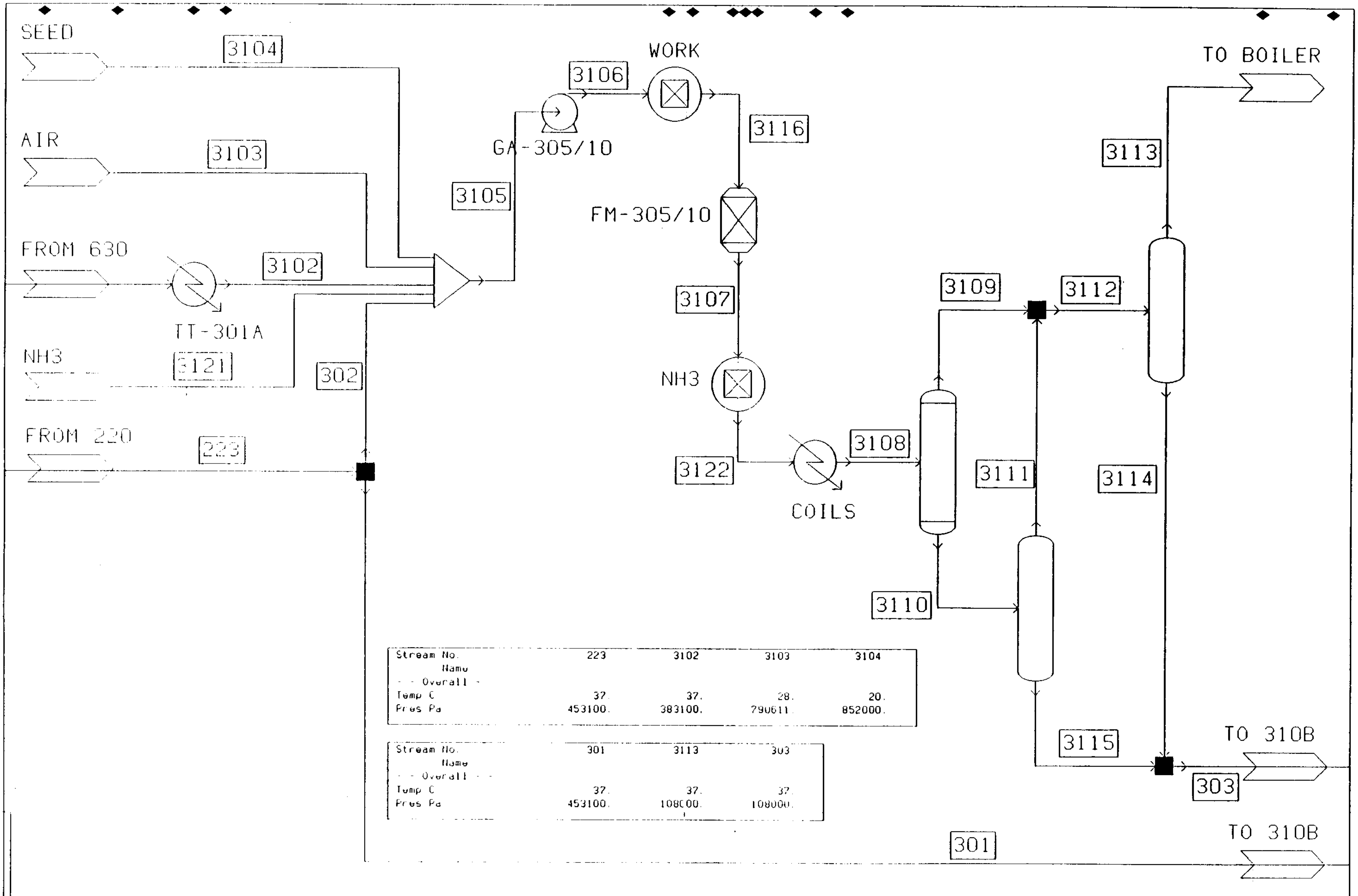
The version of CHEMCAD licensed by Chem Systems can only model continuous processes. As such, any batch processes such as seed fermentation or cellulase production have been modelled as continuous processes using hour-averaged flows. Any equipment design will have to take this into account.

Although the xylose seed fermenters are batch, they have been modelled as continuous processes in order to integrate them into the overall simulation model.



Stream No	218	221	2201	2204	222	223	224
Name							
- Overall -							
Temp C	100	20.	100	102.	102.	37.	37.
Pres Pa	207000	207000.	108000	108000.	108000.	453100.	453100.

BESSF-220: NEUTRALIZATION



Stream No.	223	3102	3103	3104
Name				
- - Overall -				
Temp C	37.	37.	28.	20.
Pres Pa	453100.	383100.	790611.	852000.

Stream No.	301	3113	303
Name			
- - Overall - -			
Temp C	37.	37.	37.
Pres Pa	453100.	108000.	108000.

BESSF-310A: XYLOSE SEED FERMENTATION

Recycle water (cooled to 37°C via TT-301A) is mixed with inoculum, air (0.2 vvm) and ammonia as feed to the xylose seed fermentation. Water addition was manually controlled to supply the specified 2 weight percent glucose and xylose in water.

Since no data was available on acid formation, ammonia consumption for pH control was assumed to be zero. Any ammonia added for neutralization would carry through the process, since no acids would be present to consume ammonia. This ammonia would then act as dissolved ammonia in the simulator, and adversely affect downstream flash calculations, as well as become present in the vents where in reality there is none.

Ammonia was used as the nitrogen source for cellmass growth. This addition was controlled ("NH_3") to insure zero ammonia was left in the reactor products stream.

The agitators GA-305,306,307,308,309,310 were modelled by controlling the pressure increase of the pump as previously discussed.
The seed fermenters have been modelled as a single continuous adiabatic reactor using the following stoichiometries:

C6 sugars (100 percent conversion)

$$100\ C_6H_{12}O_6 + 919\ \text{Air} + 89.7\ NH_3 \dashrightarrow 3.9\ C_{100}H_{164}N_{23}O_{39} + 210\ CO_2 + 415\ H_2O + 726\ N_2$$

C5 sugars (100 percent conversion):

$$100\ C_5H_{10}O_5 + 771\ \text{Air} + 74.7\ NH_3 \dashrightarrow 3.25\ C_{100}H_{164}N_{23}O_{39} + 175\ CO_2 + 346\ H_2O + 609\ N_2$$

This results in a cell yield of 0.5 grams cellmass per gram sugar consumed.

Although the reactor could have been simulated in isothermal mode, CHEMCAD does not model heat sinks or sources within a unit operation. Only the resultant heat necessary to maintain the reaction product temperature at the inlet temperature is provided. Therefore, an external exchanger was provided to simulate an isothermal reactor with heat removal using coils supplied with 10°C chilled water, and assuming a 3°C rise. The reactor exit temperature (simulated as the exit from the heat exchanger) is set at 37°C.

For cell growth, a heat of reaction of -1.08 x 10^6 kJ/kmol glucose converted to cellmass was used. It was also assumed that -1.06 x 10^6 kJ/kmol was the same for xylose and arabinose.

Where from?

The reaction products are then sent through a series of flashes to model the vapor stream coming off the fermenters. This stream is sent to the boiler for incineration.

(b) BESSF-310B: Xylose Fermentation

Seed from BESSF-310A (303) and bypassed hydrolyzate (301) are mixed with ammonia into the xylose fermenters. Similar to the seed fermenters, ammonia addition is controlled to provide a zero ammonia flow out of the reactor, and the pump pressure increase in controlled to simulate heat of mixing.

The following reactions have been modelled in one reactor, under adiabatic conditions:

C6 sugars (85.5 percent conversion):

$$C_6H_{12}O_6 \dashrightarrow 2\ C_2H_5OH + 2\ CO_2$$

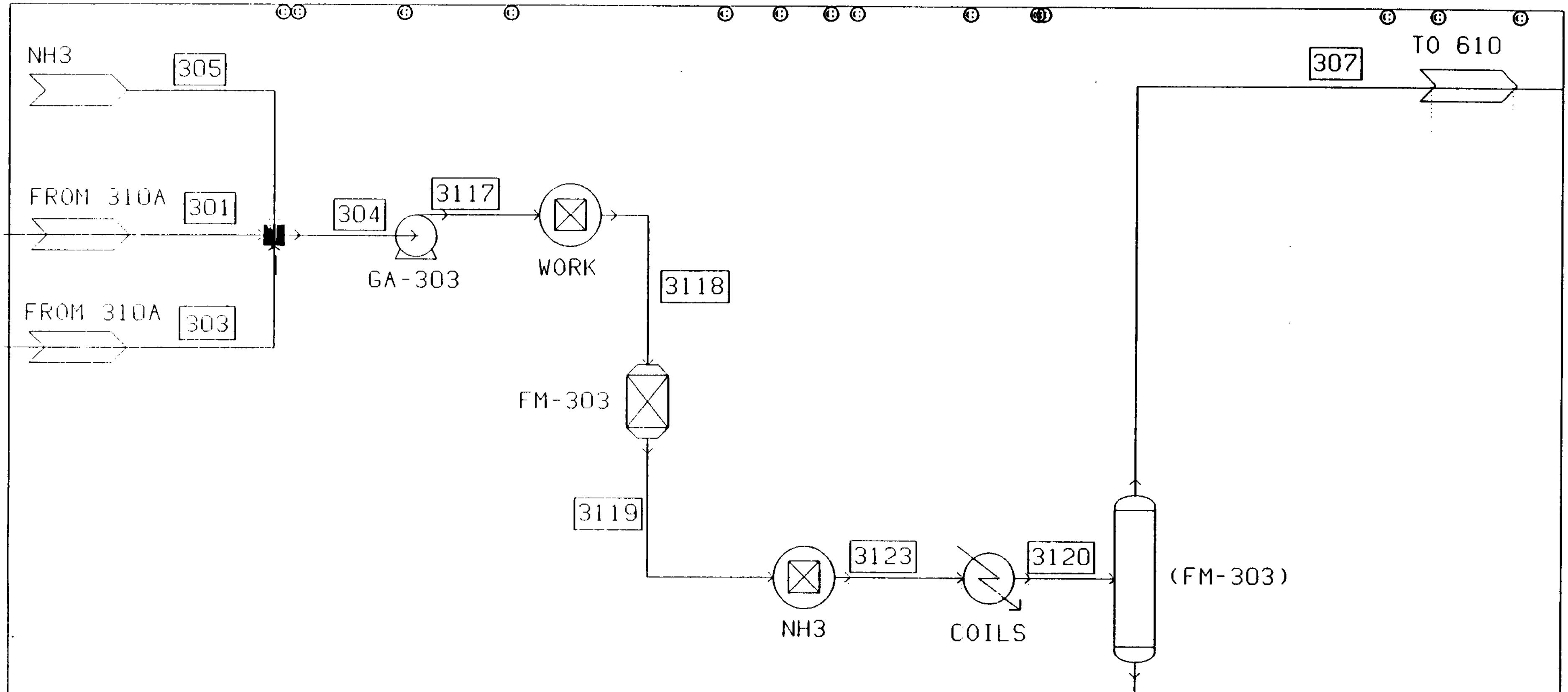
C5 sugars (85.5 percent conversion):

$$3\ C_5H_{10}O_5 \dashrightarrow 5\ C_2H_5OH + 5\ CO_2$$

No cell growth occurs during anaerobic fermentation has been assumed.

While the SERI 1991 report modelled six fermenters separately for the purposes of estimating ethanol losses via CO_2 entrainment, CHEMCAD results indicate modelling the reactor as six units or one unit makes no appreciable difference in the quantity of ethanol leaving with the vent gases. For simplicity, therefore, this model uses one reactor to model the fermentation. Vent emissions are collected in a manifold and sent to the downstream vent scrubber (AS-604) for ethanol recovery.

External coils again serve to simulate the use of internal cooling coils for isothermal operation to estimate required cooling duty, using 10°C chilled water. Exit temperature is set at 37°C. Heat of reaction for pentose fermentation was set at -6.2×10^5 kJ/kmol pentose sugar consumed, based on Perry's Handbook data.(1)



Stream No	301	303	304	305	306	307	308	3117
Name								
- - Overall - -								
Temp C	37.	37	37.	20.	38.	38.	38.	37.
Pres Pa	[illegible]	108000.	108000.	425000.	108000.	108000.	453000.	108091.

BESSF-310B: XYLOSE FERMENTATION

4. Area 400: Cellulase Production

The version of CHEMCAD licensed by Chem Systems can only model continuous processes. As such, any batch processes such as seed fermentation or cellulase production have been modelled as continuous processes using hour-averaged flows. Any equipment design will have to take this into account.

Although cellulase production is a batch process, the cycle time is 12 hours, which makes for a simple transition to continuous: all sizes and loads for the continuous model are half actual. This does not affect the simulation, since the material balance was already hourly averaged for continuous material balance reporting.

(a) BESSF-410A: Cellulase Seed Fermenters

Recycle water (4101) is cooled to 28°C in a two step heat exchanger: the first using tower water, the second using chilled water. The cooled recycle water is mixed with air, ammonia, inoculum and neutralized hydrolyzate (224) in the cellulase seed fermenters. The air rate has been set at 0.2 vvm. Ammonia addition has been controlled to give a zero ammonia flow in the reactor products.

As in xylose seed fermentation, the agitator has been simulated using an inefficient pump. Water addition is manually adjusted to provide a 5 percent cellulose/xylose concentration in water.

The following reactions have been modelled in one reactor (FM-401/4), under adiabatic mode:

C6 sugars (100 percent conversion):

$$100\ C_6H_{12}O_6 + 919\ Air + 89.7\ NH_3 \dashrightarrow 3.9\ C_{100}H_{164}N_{23}O_{39} + 210\ CO_2 + 415\ H_2O + 726\ N_2$$

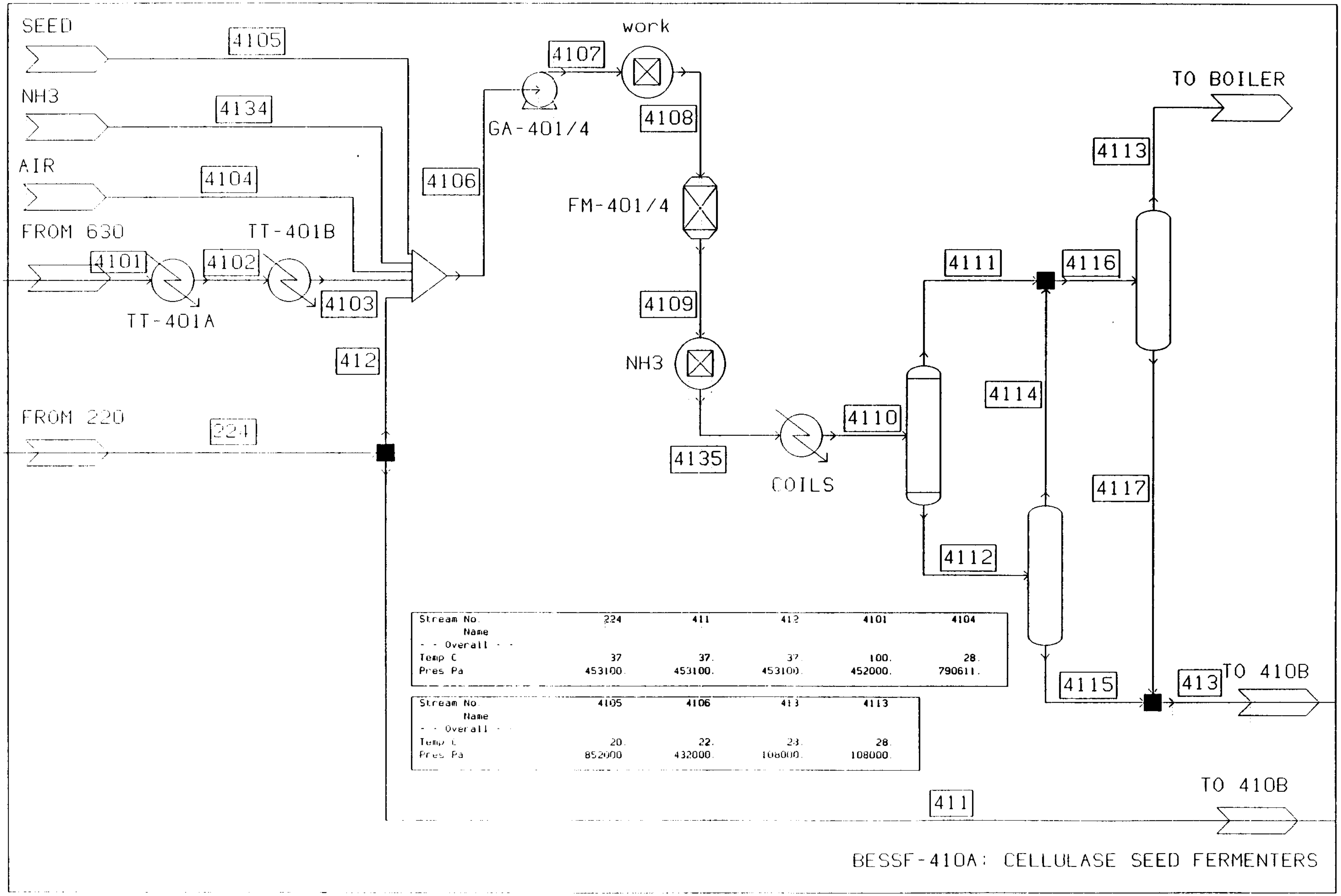
C5 sugars (100 percent conversion):

$$100\ C_5H_{10}O_5 + 771\ Air + 74.7\ NH_3 \dashrightarrow 3.25\ C_{100}H_{164}N_{23}O_{39} + 175\ CO_2 + 346\ H_2O + 609\ N_2$$

Cellulose, mannan, galactan (100 percent conversion):

$$100\ C_6H_{10}O_5 + 919\ Air + 89.7\ NH_3 \dashrightarrow 3.9\ C_{100}H_{164}N_{23}O_{39} + 210\ CO_2 + 315\ H_2O + 726\ N_2$$

Once again, ammonia is used as the nitrogen source for cell growth. It has also been assumed that *T. reesei* has the same empirical composition as *E. coli*.



Stream No.	224	411	412	4101	4104
Name					
- - Overall - -					
Temp C	37	37.	37	100.	28.
Pres Pa	453100.	453100.	453100.	452000.	790611.

Stream No.	4105	4106	413	4113
Name				
- - Overall - -				
Temp C	20.	22.	23.	28.
Pres Pa	852000	432000.	108000.	108000.

BESSF-410A: CELLULASE SEED FERMENTERS

External cooling coils simulate chilled water cooling duty. Chilled water rises from 10°C to 13°C, and flow is controlled to maintain exit temperature at 28°C.

After a series of flashes to simulate vent gas composition, the cellulase seed is sent to cellulase production.

(b) BESSF-410B: Cellulase Production

Cellulase seed (413) and neutralized hydrolyzate (411) are mixed with substrate (simulated as glucose), ammonia (nutrient) and air (set at 0.2 vvm. The total air flow was prorated by 5.7/6 to account for batch cycle time.) are mixed into the cellulase fermenters. Again, a pump is used to simulate heat of mixing. Water addition is manually adjusted to provide a five weight percent cellulose/xylose substrate.

The cellulase production fermenters are broken down into two reactors. The first reactor assumes the duty of cell growth, with a conversion of 47 percent. The remaining 53 percent of substrate (cellulose, mannan, galactan, and sugars) is reacted to 100 percent conversion in a second reactor which assumes the duty of cellulase production. This split was done simply for sake of ease, and to better monitor the effects of each set of reactions: cellulase production and cellmass growth.

The first reactor models the following cellmass growth reactions adiabatically:

C6 sugars (32.5 percent conversion)

$$100\ C_6H_{12}O_6 + 919\ Air + 89.7\ NH_3 \dashrightarrow 3.9\ C_{100}H_{164}N_{23}O_{39} + 210\ CO_2 + 415\ H_2O + 726\ N_2$$

C5 sugars (32.5 percent conversion):

$$100\ C_5H_{10}O_5 + 771\ Air + 74.7\ NH_3 \dashrightarrow 3.25\ C_{100}H_{164}N_{23}O_{39} + 175\ CO_2 + 346\ H_2O + 609\ N_2$$

The second reactor models the following cellulase production reactions, also adiabatically:

C6 sugars (100 percent conversion):

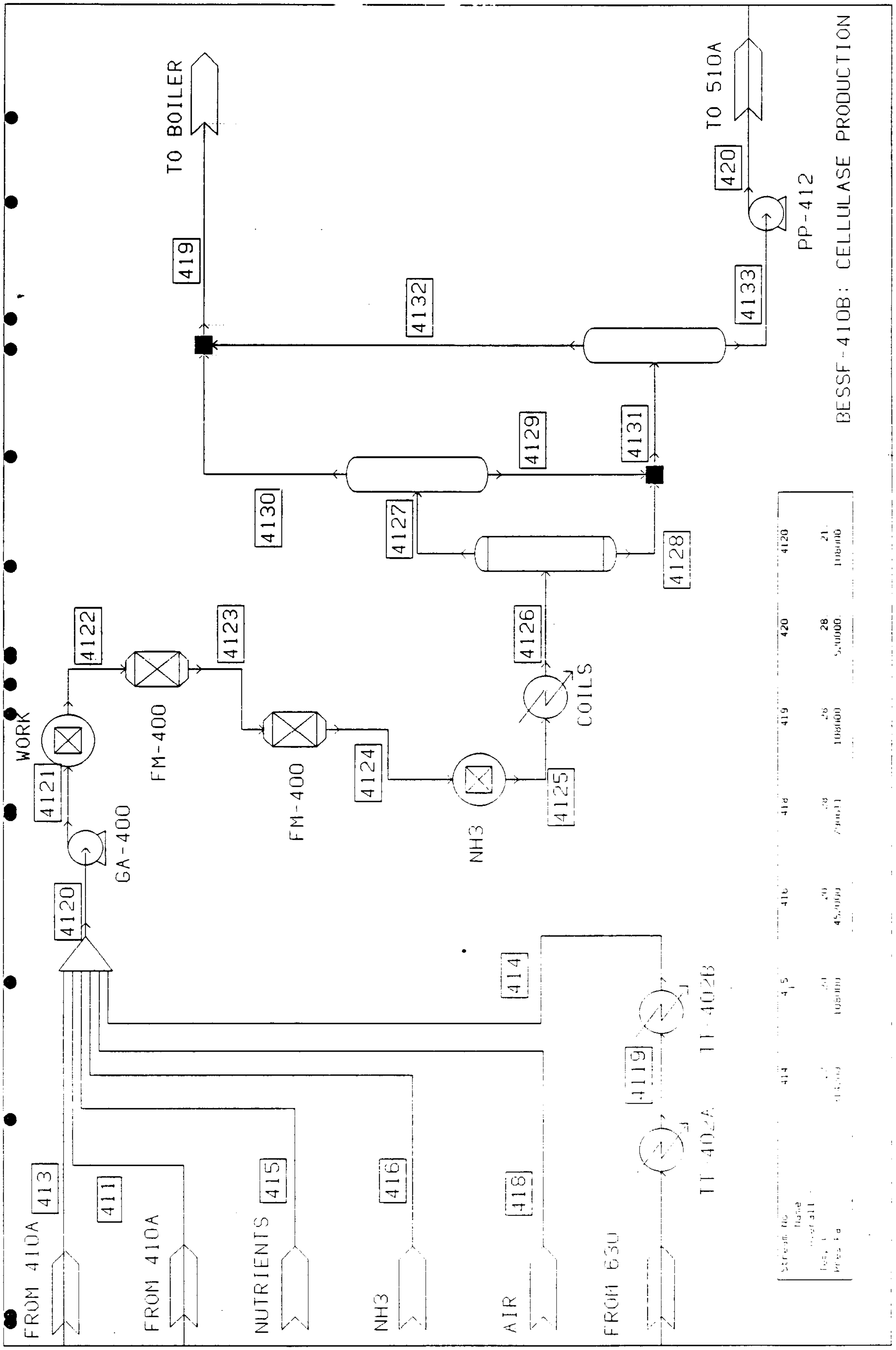
$$100\ C_6H_{12}O_6 + 1895\ Air + 57.4\ NH_3 \dashrightarrow 1.98\ C_{100}H_{157}N_{29}O_{31} + 402\ CO_2 + 531\ H_2O + 1497\ N_2$$

C5 sugars (100 percent conversion):

$$100\ C_5H_{10}O_5 + 1490\ Air + 53.1\ NH_3 \dashrightarrow 1.83\ C_{100}H_{157}N_{29}O_{31} + 317\ CO_2 + 436\ H_2O + 1177\ N_2$$

Cellulose, mannan, galactan (100 percent conversion):

$$100\ C_6H_{10}O_5 + 1895\ Air + 57.4\ NH_3 \dashrightarrow 1.98\ C_{100}H_{157}N_{29}O_{31} + 402\ CO_2 + 431\ H_2O + 1497\ N_2$$


BESSF-410B: CELLULASE PRODUCTION
TO BOILER
TO 510A
PP-412
419
420
4132
4133
4131
4129
4130
4127
4128
4126
COILS
4122
4123
WORK
FM-400
FM-400
4121
4124
NH3
4125
GA-400
4120
414
4119
TT-402B
TT-402A
FROM 410A
413
411
FROM 410A
NUTRIENTS
415
NH3
416
AIR
418
FROM 630

Heat of reaction was manually set at -1.56 x 10^6 kJ/kmol pentose (-4,456 btu/lb); and -1.98 x 10^6 kJ/kmol cellulose.

An external heat exchanger simulates the internal cooling coils, which maintain the reactor exit temperature at 28°C.

After a series of flashes to estimate vent gas composition, the cellulase is sent to SSF.

5. Area 500: Simultaneous Saccharification and Fermentation (SSF)

(a) BESSF-510A: SSF Seed Fermentation

Inoculum, air, substrate (simulated as glucose) and nutrients (simulated as "ammonia") are added with cellulase (420) and feed from xylose fermentation (308). The resultant mixture is heated using the simulated heat addition of the agitator via pump GA-501/6, and sent to the SSF seed fermenter. The air rate, normally 0.2 vvm, was simulated at 0.1 vvm to account for batch cycle times.

The SSF seed fermenter simulates the production of *S. cerevisiae* which is assumed to have the same empirical composition as *T. reesei* and *E. coli*. The following reactions occur in FM-501/6:

C6 sugars (100 percent conversion):

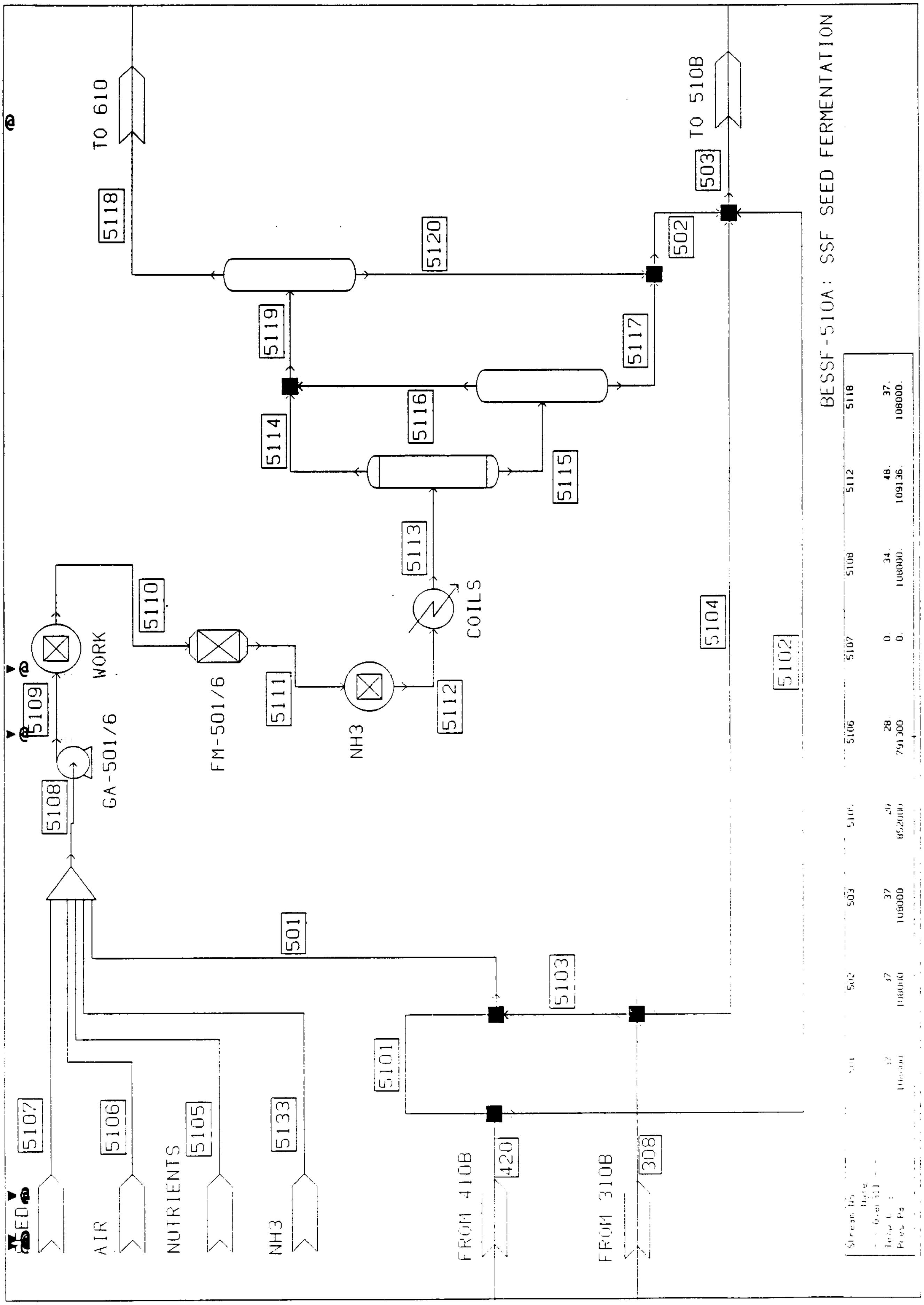
$$100\ C_6H_{12}O_6 + 919\ Air + 89.7\ NH_3 \dashrightarrow 3.9\ C_{100}H_{164}N_{23}O_{39} + 210\ CO_2 + 415\ H_2O + 726\ N_2$$

Cellulose, mannan, galactan (14.6 percent conversion):

$$100\ C_6H_{10}O_5 + 919\ Air + 89.7\ NH_3 \dashrightarrow 3.9\ C_{100}H_{164}N_{23}O_{39} + 210\ CO_2 + 315\ H_2O + 726\ N_2$$

An external heat exchanger is used to simulate cooling coils, which maintain the reactor exit temperature at 37°C via 10°C chilled water.

After a series of flashes which used to estimate vent vapor composition, the seed is mixed with all remaining flows which are used as feed for SSF.


BESSF-510A: SSF SEED FERMENTATION
SEED
AIR
NUTRIENTS
NH3
FROM 410B
FROM 310B
TO 610
TO 510B
5107
5106
5105
5133
420
308
5101
5103
501
5108
GA-501/6
5109
WORK
5110
FM-501/6
5111
NH3
5112
COILS
5113
5114
5115
5116
5117
5119
5120
5118
502
503
5104
5102
Stream No.
Temp C
Pres Pa
5118 37. 108000.
5112 48. 109136.
5108 34. 108000.
5107 0. 0.
5106 28. 791300
503 37 108000

(b) BESSF-510B: SSF

SSF agitation is simulated using pump GA-500. The heated feed is then passed through the SSF reaction.

The SSF reactor has been divided into two steps: the first hydrolyses the cellulose and hemicellulose components into their respective sugars, and the second step ferments the sugars into ethanol and fermentation by-products. This has been carried out in sequential reactors. Using one reactor would run all reactions simultaneously, and the sugars formed from the hydrolysis step would not be affected by the fermentation reactions.

The first reaction models the following reactions adiabatically:

Cellulose (Mannan, Galactan) hydrolysis (87 percent conversion for cellulose, 80 percent others)

$C_6H_{10}O_5 + H_2O \text{ --> } C_6H_{12}O_6$

Xylan (arabinan) hydrolysis (80 percent conversion)

$C_5H_8O_4 + H_2O \text{ --> } C_5H_{10}O_5$

The second reactor, also in adiabatic mode, models the following reactions:

C6 sugars (92.0 percent conversion):

$C_6H_{12}O_6 \text{ --> } 2\ C_2H_5OH + 2\ H_2O$

C6 sugars, by-product formation (0.5 percent conversion):

$C_6H_{12}O_6 \text{ --> } C_6H_6O_3 + C_2H_4O + CO_2$

Fusel oil formation (0.1 percent conversion):

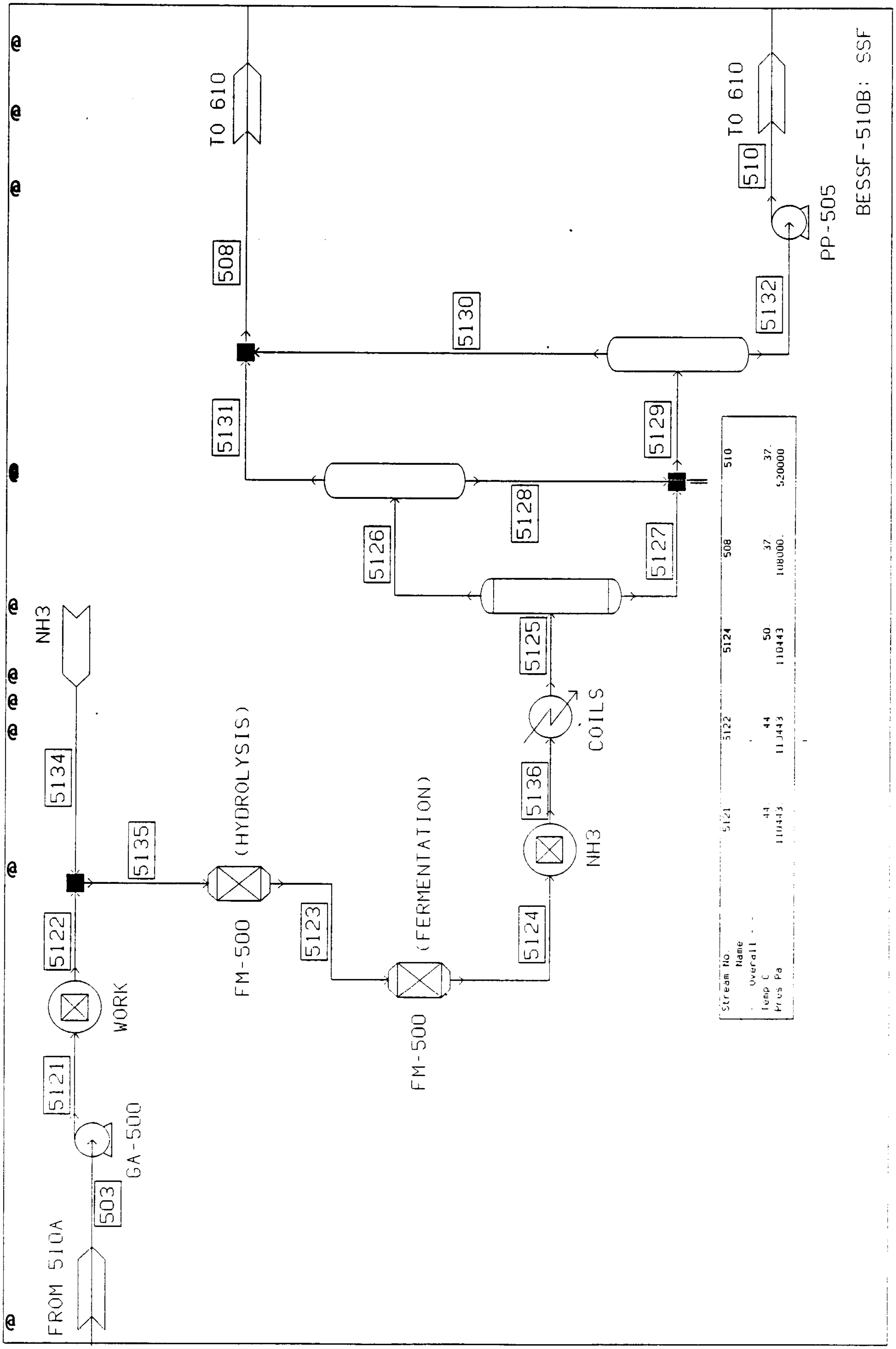
$C_6H_{12}O_6 \text{ --> } C_5H_{12}O + CO_2 + 1.5\ O_2$

Anaerobic Cell Growth (7.4 percent conversion):

$100\ C_6H_{12}O_6 + 100\ C_2H_5OH + 46\ NH_3 \text{ --> } 2\ C_{100}H_{164}N_{23}O_{39} + 200\ C_3H_8O_3 + 5\ H_2O + 8.5\ O_2$

The nutrient source for cell growth is ammonia, which is controlled to yield zero ammonia flow in the reactor product stream.

Once again, the reactor products are maintained at 37°C using an external heat exchanger to simulate internal cooling coils.



Stream No.	5121	5122	5124	508	510
Name					
Overall					
Temp C	44.	44	50.	37.	37.
Pres Pa	110443.	110443	110443	108000.	520000

After a series of flashes to estimate the vent vapor composition and ethanol losses, the fermented mash is sent downstream for ethanol purification via pump PP-505.

6. Area 600: Ethanol Purification

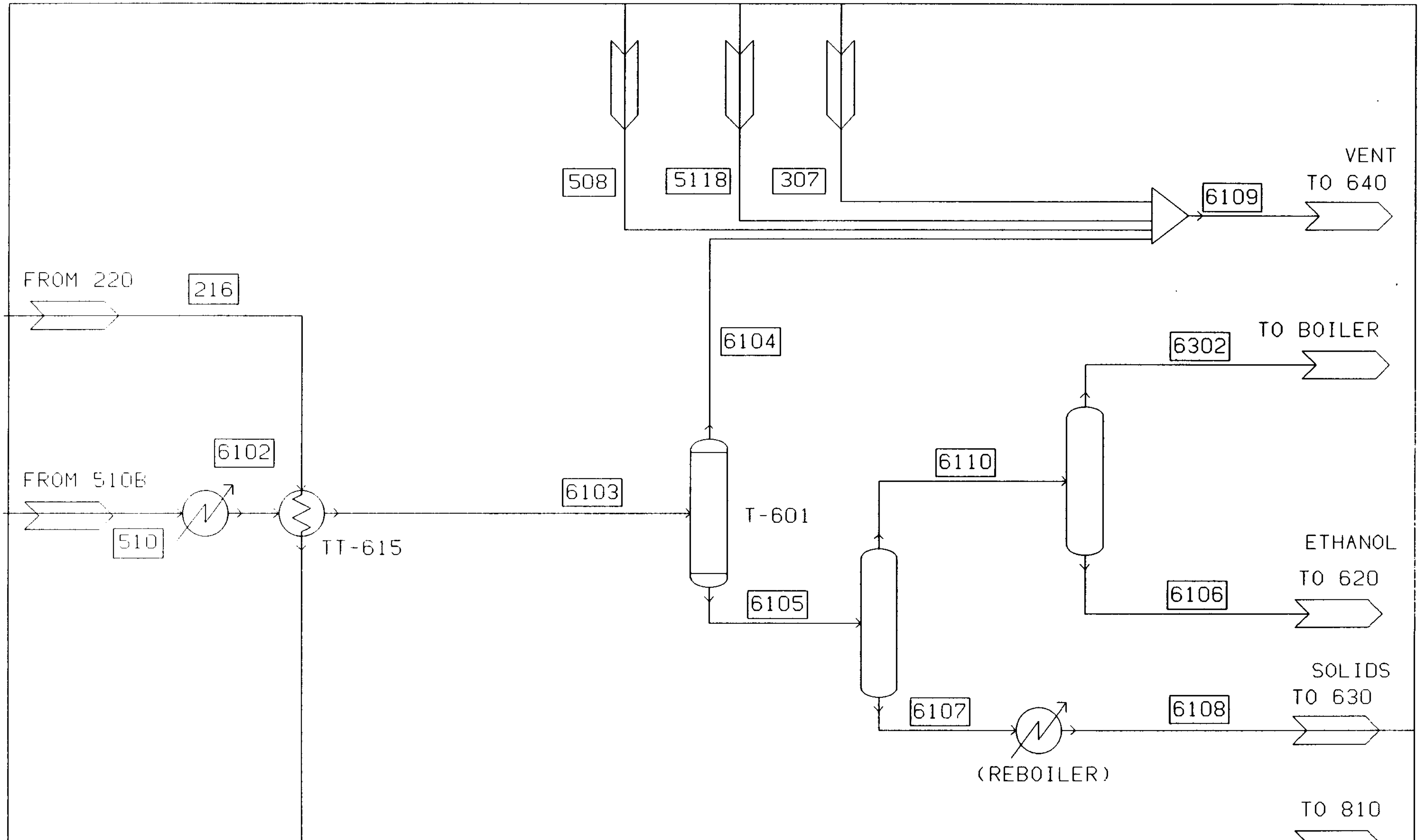
Part of area 600 was modelled on a different simulator than the first part of the process for reasons described above.

(a) BESSF-610: Degasser

Mash from SSF fermentation (510) is preheated first by using the overhead vapors from AS-602, using TT-623, then by condensing the vapors coming off the prehydrolysis blowdown tank (216), using heat exchanger TT-615. The condensed vapors are sent to wastewater recovery. TT-623 is modelled under a later flowsheet. In this section it serves only as a place-holder. The hot mash is then sent to the degasser drum (T-601) where dissolved CO_2 and part of the light end impurities are flashed off to stabilize the beer still. The vapors are sent to ethanol recovery to capture any lost ethanol.

The liquids and solids at this point are separated into two streams: (6110) and (6107). This is necessary to prevent solids from interfering with the simulation of the distillation area. The solids are be recombined with the wastewater from the beer still in a later step, which already simulates reality. To account for the additional reboiler duty needed to heat the solids up to reboiler temperature, a mock-reboiler has been added to heat the solids stream to 149°C, which is the approximate temperature of the beer still bottoms. The duty of this mock reboiler is added to the beer still reboiler duty.

The liquids are then further separated into fusel oils plus gases, and crude ethanol. Fusel oils do not model well; they form highly non-ideal mixtures with water and ethanol, and as such has not proven possible to model without rigorous VLE data, which is unavailable at this time. They have been diverted away from the distillation units, and the units have been simulated without the fusel oils present. Should robust VLE binary interaction parameters become available for fusel oils in the future, the simulation may be better able to incorporate fusel oil design.



Stream No.	6101	6102	6103	6104	6106	6108	6109	6111
Name								
- - Overall - -								
Temp C	87.	76.	98.	98.	100.	149.	38.	0.
Pres Pa	94200.	451100.	382200.	382200.	126626.	126626.	108000.	0.

BESSF-610: DEGASSER

(b) BESSF-620: Ethanol Distillation

The liquids portion of the SSF mash are then preheated using a set of heat recovery exchangers. Stream 6106 begins at 37°C to model the heat exchangers. The flash drum was simulated previously, since only 5 components (water, ethanol, furfural, glycerol and acetaldehyde) were modelled using "ETOH-2" flowsheets (BESSF-620). It would be between TT-615 and TT-629.

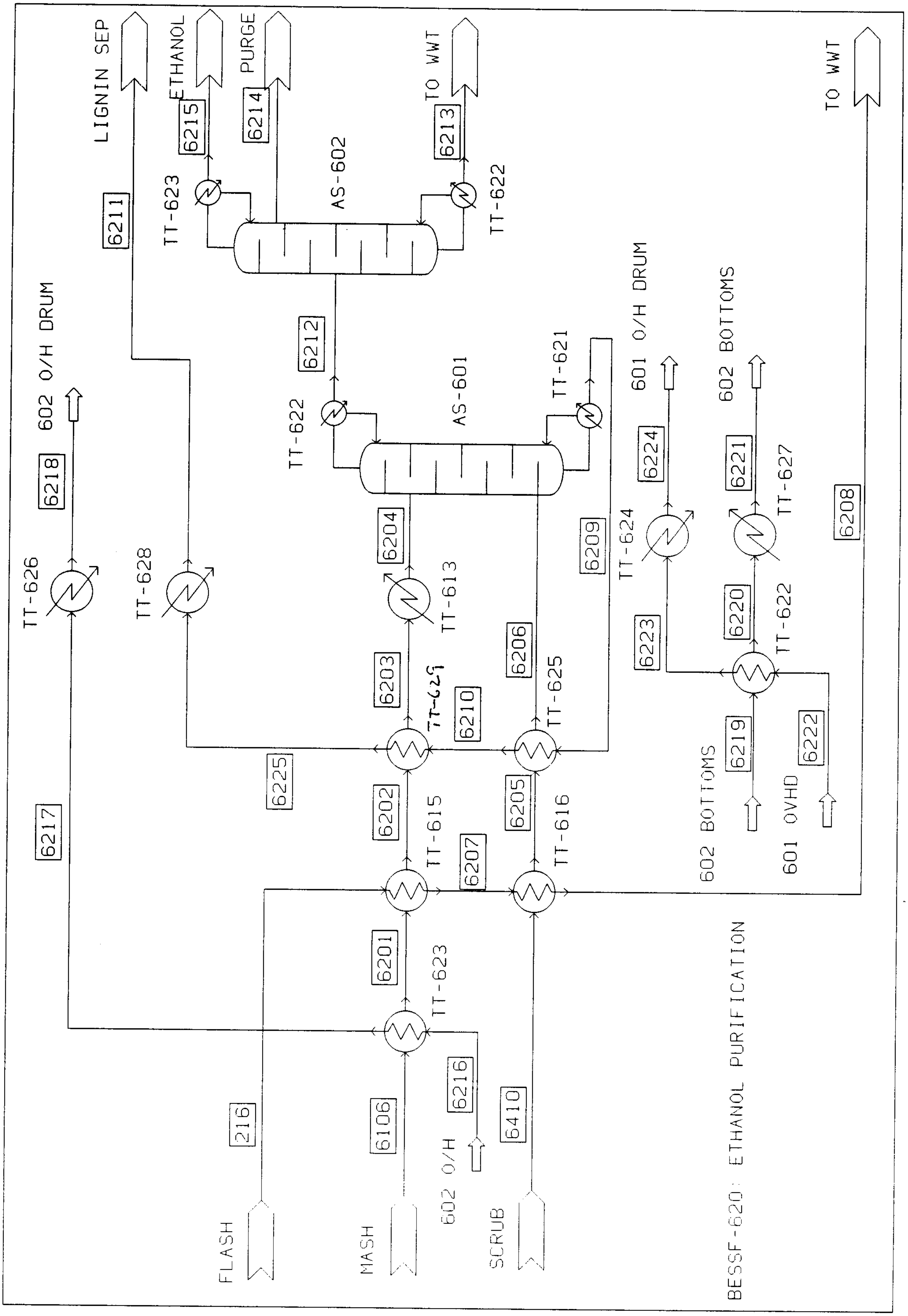
The mash is heated using the overheads from the rectification still AS-606 (TT-623, overhead condenser), then further heated using flash vapors from area 200 (TT-615), further heated using bottoms from the beer still (TT-629), and finally a trim heater to raise the mash to a feed temperature of 120°C. Exchangers were designed for a minimum approach temperature of 5°C.

The column is also fed with water from the vent scrubber (AS-604). These waters are preheated using hot flash condensate (TT-616) and bottoms from the beer still (TT-625), to raise the temperature to 120°C.

The column has been modelled as a vigorous simulations connection distillation (SCDS) unit operation, which is recommended for non-ideal separation. The column was designed to provide maximum separation in 40 stages without exceeding a 4m diameter, which is the maximum width that can be transported by highway. Larger diameters would require site fabrication, greatly increasing costs. Tray efficiency was estimated at 0.6, using sieve trays with 1.9 cm (3/4") holes.

The bottoms of the beer still are specified for 100 ppm ethanol. These are used to preheat the scrubber water and mash feeds to the column before being moderately cooled prior to lignin separation. Solids were not simulated here, for reasons stated above.

The column is operated at 417 kPa (45 psig), so that the temperature can be elevated enough to use the overhead condenser as a simultaneous reboiler for the rectification still. The overhead vapor is at about 123°C, and the bottom of the rectification still is at 113°C. A trim cooler (TT-624) is supplied to account for the entire cooling duty of the column (duties of TT-622 and TT-624 add up to AS-601 cooling duty). Because Chem CAD does not allow heat integration for overhead condensers or reboilers, TT-622 was modelled



BESSF-620: ETHANOL PURIFICATION

separately using the vapor from AS-601 stage 2 and liquid from AS-602 stage 69. The pressure of stream 6222 is slightly lower than the top of AS-601 to account for any pressure drop in the vapor to the condenser/reboiler, and to ensure the vapor fraction remained 1 (100 percent vapor at dew point) for proper exchangers simulation.

The overhead product from AS-601 is sent directly to the rectification still (AS-602). The still has 70 stages and is operated at 105 kPa and a reflux ratio of 4. Reboiler duty is supplied by the overhead condenser of the beer still (TT-622) plus a trim heater (TT-627). TT-622 was specified to supply 80 percent of the required duty, with the remaining 20 percent by the trim heater. The overhead condenser (TT-623) is cooled using feed mash (80 percent of the required cooling duty) with the remaining 20 percent of the cooling duty supplied by the trim overhead condenser (TT-626).

The bottoms product is sent to wastewater treatment. The column was specified for a 100 ppm ethanol concentration in the wastewater.

Fuel oil separation was not simulated here for reasons stated above.

Fermentation of biomass creates a multitude of fermentation by-products. These are, but not limited to: acetaldehyde, glycerol, fusel oils, and acetic acid. Except for glycerol, and prehydrolysis byproducts, which have a much lower relative volatility than water with respect to ethanol, these light-end impurities have a tendency to travel with the ethanol.

At first glance, some of these impurities seem heavier than water. However, these impurities are in very low concentrations, are generally immiscible with water. Therefore, when water is present in large concentrations, the relative volatilities of these impurities is higher than ethanol, which drives them out with the ethanol during distillation.

Industry practice is to insert a middle column between the beer still and the rectification still. Water is fed at the top of this column from the fusel oils washing step. This is not only to recover any ethanol entrained with the fusel oils, but to strip out the light ends by a process known as hydroselection: introducing water to force the relative volatilities of the impurities to a level higher than that of ethanol. Thus the overheads from this middle stripping column are the impurities, while the bottoms are ethanol, water and fusel oils, which are sent to further processing in the rectification still.

This design, after much effort, would not converge on CHEMCAD 3.03. The probable cause of non-convergence is the lack of binary interaction parameter for all the light end components, products and water. The highly non-ideal nature of the separation (especially for such pairs as fusel-oils-water, etc.) and the presence of solids, coupled with lack of adequate NRTL data resulted in non-convergence. Until better data becomes available, either Henry's constants, NRTL or other liquid activity parameters, it is better to design the plant on available data than speculate on the basis of other plants.

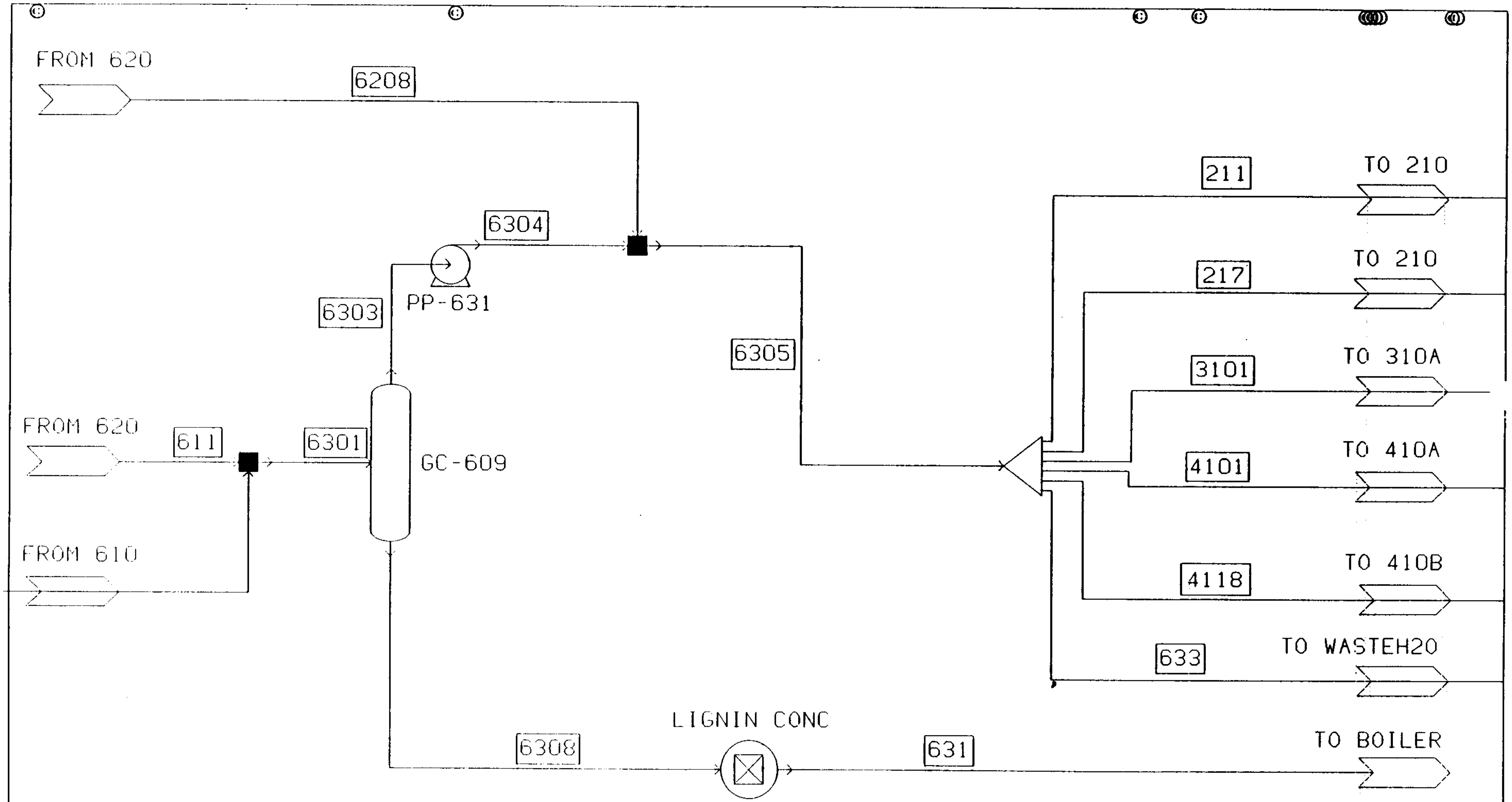
The near azeotropic overhead product (94.7 weight percent ethanol, 5.2 percent water) is sent to ethanol storage. The column also has a purge: 0.4 percent of the vapor leaving stage 2 (tray 1) is purged to the boiler to prevent buildup of impurities, namely acetaldehyde. With a reflux ratio of 4, 0.4 percent represents 2 percent of the overhead product (0.004 x (4+1) = 0.02), and was chosen because the acetaldehyde concentration was greatest in the vapor from tray 1, and slightly less than 2 percent concentration.

The purified ethanol/water azeotrope is sent to ethanol storage for later blending with gasoline.

(c) BESSF-630: Lignin Separation

Bottoms from the beer still (611) are re-mixed with their solids. This is mixed with any impurities taken out of the fusel oils during washing (6301), and sent to a lignin concentrator (GC-609). Here the lignin is concentrated into a 40 weight percent slurry, to be used as the main fuel feed (631) to the boiler/co-generation unit. An ideal component separator unit operation was used to simulate the centrifuge.

Liquor from the concentrator is pumped and split between wastewater sent to treatment and recycle water. The recycle water is diluted and cooled with process water (634), which is from well water available at 15°C. This recycle water is then sent back to prehydrolysis (211, 217), xylose seed fermentation (3101), cellulase seed fermentation (4101) and cellulase production (4118). The simulation was run three times, for a recycle water composition change of less than five percent.



Stream No	6111	611	6108	634	6401	6301	6303	6304	633	6306	631
Name											
- - Overall											
Temp C	0	114	106	15	15.	102.	100.	100.	100.	82.	100.
Pres Pa	0	452000	126626	452000	452000.	108000.	108000	452000.	452000.	452000.	108000.

BESSF-630: LIGNIN SEPARATION

(d) BESSF-640: Vent Scrubber

All ethanol containing vents are directed to AS-604, the vent scrubber. The scrubber is a packed tower which uses cold water in direct contact to condense and recover ethanol lost in the vents. This is much more efficient for dilute recovery streams than vent condensers.

The column has no reboiler or condenser. The water flow to the top is controlled to recover 95 percent of the incoming ethanol. The remaining vapors are passed through K-642, the scrubber blower, and are sent to the boiler for incineration. The blower is designed for an inlet pressure of minus 10 inches water column and an outlet of 15 inches water column. The dilute ethanol in water is sent to the beer still for ethanol recovery.

7. Area 700: Tank Farm

This area has not been simulated but is included in the Lotus 1-2-3 cost model.

8. Area 800: Wastewater Treatment

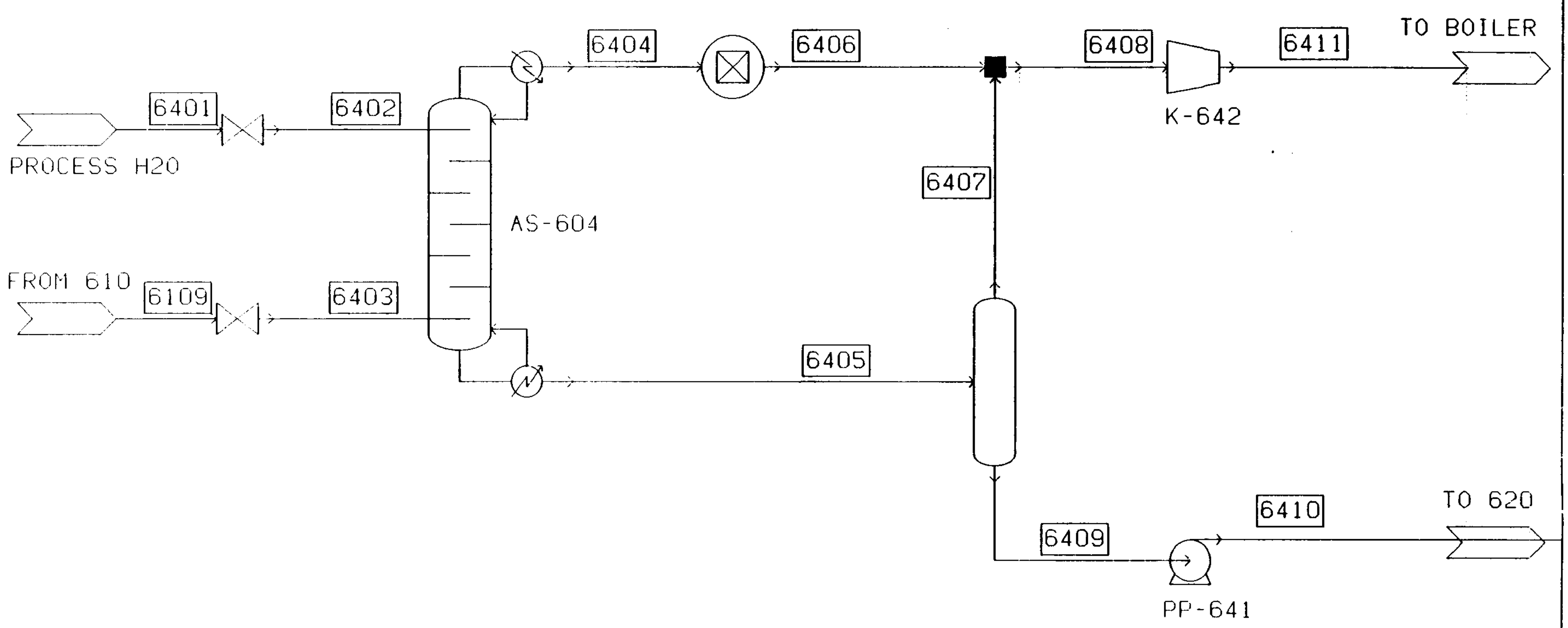
Wastewater treatment has been modelled to the extent necessary to simulate methane production from anaerobic treatment, since the methane is used as a fuel in the boiler.

NREL provided results from a separate wastewater study, completed by CH2M/Hill(4). The results of this study have been used as the basis for the wastewater treatment area design, except that the organic loading rate has been doubled to 5 kg/d/m^3.

The area has been broken into two flowsheets: BESSF-810 and BESSF-820, anaerobic biotreatment and aerobic treatment, respectively.

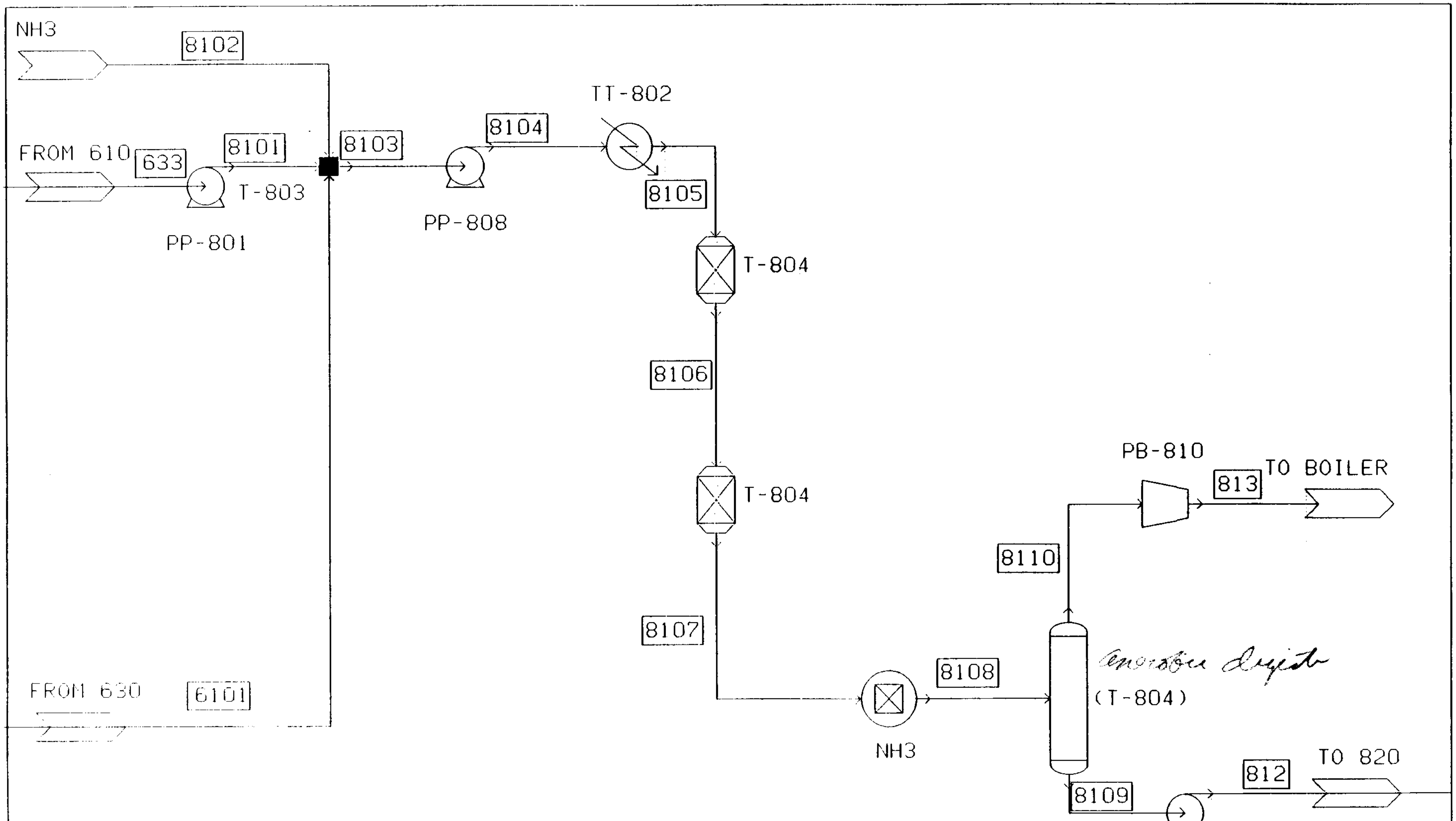
(a) BESSF-810: Wastewater Treatment, Anaerobic Biotreatment

Wastewaters are collected and mixed in the equalization tank (T-803). Ammonia is provided as a nitrogen source for cell growth. The equalized wastes are pumped via PP-808, cooled to 35°C using cooling tower water (TT-802) and sent to anaerobic biotreaters, where a variety of biological agents convert 90 percent of incoming organic material into methane, CO_2 and cellmass.



Stream No. Name - - Overall - -	6109	6401	6402	6403	6404	6405	6406	6409	6410	6411
Temp C	37	15.	15.	36.	29.	37.	29.	37.	37.	39.
Pres Pa	106000	452000	101000.	101000.	101000.	105500.	101000.	105500.	405500.	108000.

BESSF-640: VENT SCRUBBER



Stream No	8102	8103	8104	812	813
Name					
- - Overall					
Temp C	[illegible]	99	99	35	41
Pres Pa	[illegible]	108000	411000	404000	108000

BESSF-810: WASTEWATER TREATMENT
ANAEROBIC BIOTREATMENT

The reactor has been simulated into two parts, since more than twenty reactions occur. Twenty reactions is the maximum that can be simulated in any one reactor in CHEMCAD. Also, since cellmass growth is simulated as using CH_4 and CO_2 as building blocks, using the first reactor for cellmass growth would underestimate the actual cellmass growth rate.

The first reactor simulates anaerobic combustion, using the following reactions:

Cellulose, mannan, galactan (90 percent conversion):
$C_6H_{10}O_5 + H_2O \dashrightarrow 3\ CO_2 + 3\ CH_4$
Xylan, arabinan (90 percent conversion):
$2\ C_5H_8O_4 + 2\ H_2O \dashrightarrow 5\ CO_2 + 5\ CH_4$
C6 sugars (90 percent conversion):
$C_6H_{12}O_6 \dashrightarrow 3\ CO_2 + 3\ CH_4$
C5 sugars (90 percent conversion):
$2\ C_5H_{10}O_5 \dashrightarrow 5\ CO_2 + 5\ CH_4$
Ethanol (90 percent conversion):
$2\ C_2H_5OH \dashrightarrow CO_2 + 3\ CH_4$
HMF (90 percent conversion):
$C_6H_6O_3 + 3\ H_2O \dashrightarrow 3\ CO_2 + 3\ CH_4$
Furfural (90 percent conversion):
$2\ C_5H_4O_2 + 6\ H_2O \dashrightarrow 5\ CO_2 + 5\ CH_4$
Glycerol (90 percent conversion):
$2\ C_3H_8O_3 + 2\ H_2O \dashrightarrow CO_2 + 5\ CH_4 + 3\ O_2$
Acetaldehyde (90 percent conversion):
$2\ C_2H_4O + 2\ H_2O \dashrightarrow CO_2 + 3\ CH_4 + O_2$
Fusel Oils (90 percent conversion):
$2\ C_5H_{12}O + 6\ H_2O \dashrightarrow CO_2 + 9\ H_2O + 3\ O_2$
Cellulase (90 percent conversion):
$4\ C_{100}H_{157}N_{29}O_{31} + 362\ H_2O \dashrightarrow 62\ CO_2 + 338\ CH_4 + 58\ N_2 + 181\ O_2$
Soluble Solids (90 percent conversion):
$2\ C_{100}H_{148}O_{19} + 214\ H_2O \dashrightarrow 19\ CO_2 + 181\ CH_4 + 107\ O_2$

The second reactor simulates cellmass growth, using the following reaction:

$$383\ CO_2 + 417\ CH_4 + 184\ NH_3 \dashrightarrow 8\ C_{100}H_{164}N_{23}O_{39} + 454\ H_2O$$

While not technically correct, the above cell growth reaction is used because using individual organic components for cellmass growth would result in oxygen balance problems, as well as many complicated formula. The above reaction does accurately summarize the overall effect, since the organics must be broken down into digestible parts before the cell can use it as building block material. This also allows the organics in the first reactor to be converted at 90 percent independently of cellmass growth data.

Ammonia addition is controlled to yield a zero ammonia flowrate in the second reactor product stream (8107).

The material is then sent to a flash operation to simulate vent composition. The biogases are sent to incineration, while the liquids and entrained solids are sent for further processing.

(b) BESSF-820: Wastewater Treatment, Aerobic Biotreatment

Water from the anaerobic treater is sent to T-807, the aerobic biotreater. Oxygen from the PSA unit is sparged into the system via a sparger (GV-807). The remaining organics are aerobically treated at 100 percent conversion to CO_2 and H_2O, using the following reactions:

Cellulose, mannan, galactan:

$C_6H_{10}O_5 + 6\ O_2 \dashrightarrow 6\ CO_2 + 5\ H_2O$

Xylan, arabinan:

$2\ C_5H_8O_4 + 5\ O_2 \dashrightarrow 5\ CO_2 + 4\ H_2O$

C6 sugars:

$C_6H_{12}O_6 + 6\ O_2 \dashrightarrow 6\ CO_2 + 6\ H_2O$

C5 sugars:

$2\ C_5H_{10}O_5 + 5\ O_2 \dashrightarrow 5\ CO_2 + 5\ H_2O$

Ethanol:

$C_2H_5OH + 4\ O_2 \dashrightarrow 2\ CO_2 + 3\ H_2O$

HMF:

$C_6H_6O_3 + 6\ O_2 \dashrightarrow 6\ CO_2 + 3\ H_2O$

Furfural:

$C_5H_4O_2 + 5\ O_2 \dashrightarrow 5\ CO_2 + 2\ H_2O$

Glycerol:

$2\ C_3H_8O_3 + 7\ O_2 \dashrightarrow 6\ CO_2 + 8\ H_2O$

Acetaldehyde:

$2\ C_2H_4O + 5\ O_2 \dashrightarrow 4\ CO_2 + 4\ H_2O$

Fusel Oils:

$2\ C_5H_{12}O + 15\ O_2 \dashrightarrow 10\ CO_2 + 12\ H_2O$

Soluble Solids:

$$2\ C_{100}H_{148}O_{19} + 255\ O_2 \dashrightarrow 200\ CO_2 + 148\ H_2O$$

Cellulase:

$$C_{100}H_{157}N_{29}O_{31} + 102\ O_2 \dashrightarrow 100\ CO_2 + 35\ H_2O + 29\ NH_3$$

Cellmass does not get converted; it is taken out via clarifiers and thickeners as sludge.

Oxygen addition is controlled to supply 50 percent excess oxygen (Based on Theoretical Oxygen Demand) to the aerator.

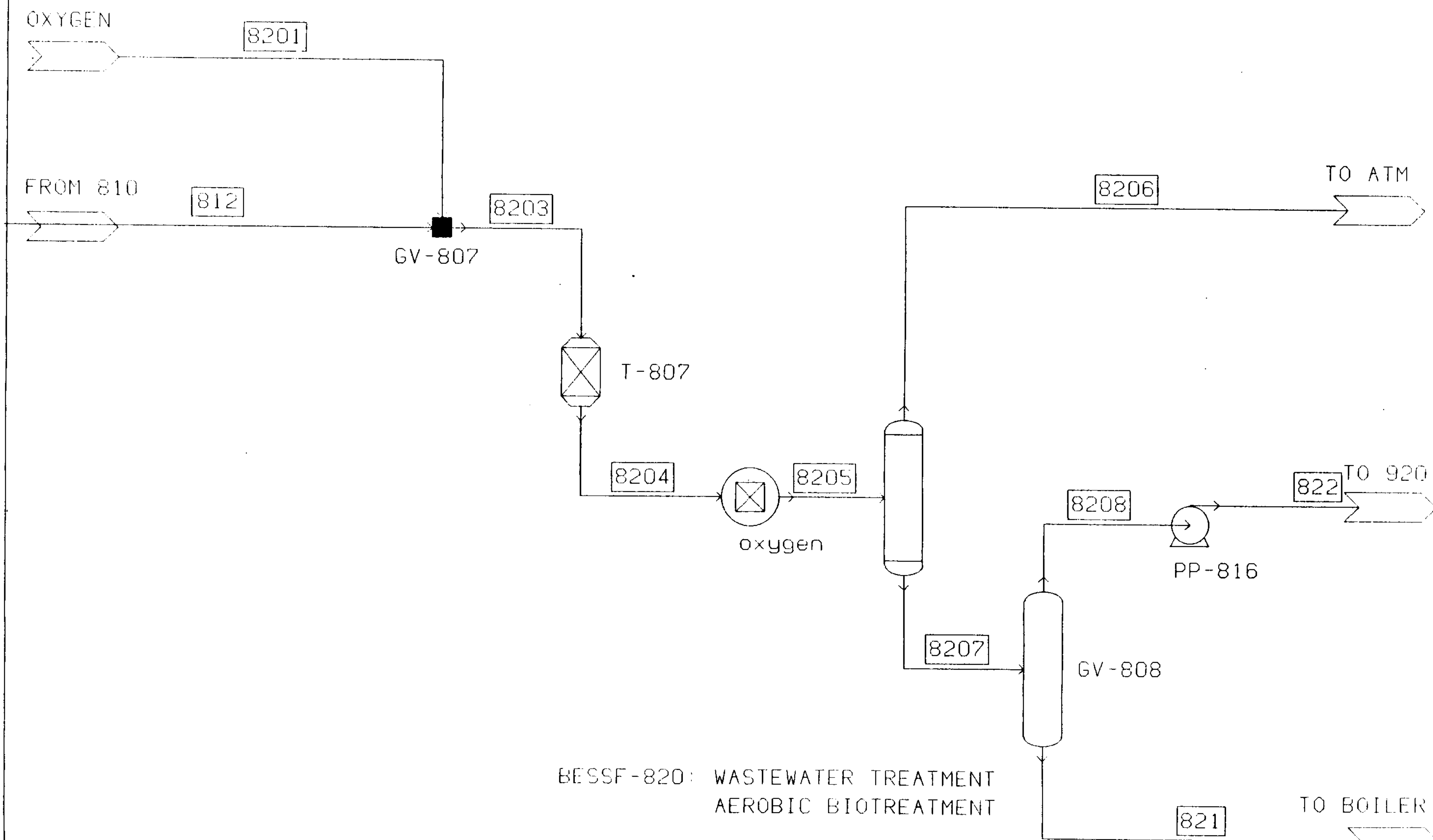
The reactor products are sent to a flash to simulate vapors sent to atmosphere (the aerator is an open-top vessel). The liquids are clarified (GV-808) and thickened, with the sludge going to the boiler as fuel, and the clarified waters are sent to the process water tank for recycle to utility service.

(c) BESSF-821: Boiler Fuels

This flowsheet summarizes the boiler feedstreams from the process. Vents are combined and sent through a boiler feed blower (except for the scrubber vent, 6411, which has a dedicated blower). Liquids and slurries are combined separately from the gases, and are sent to the boiler as well.

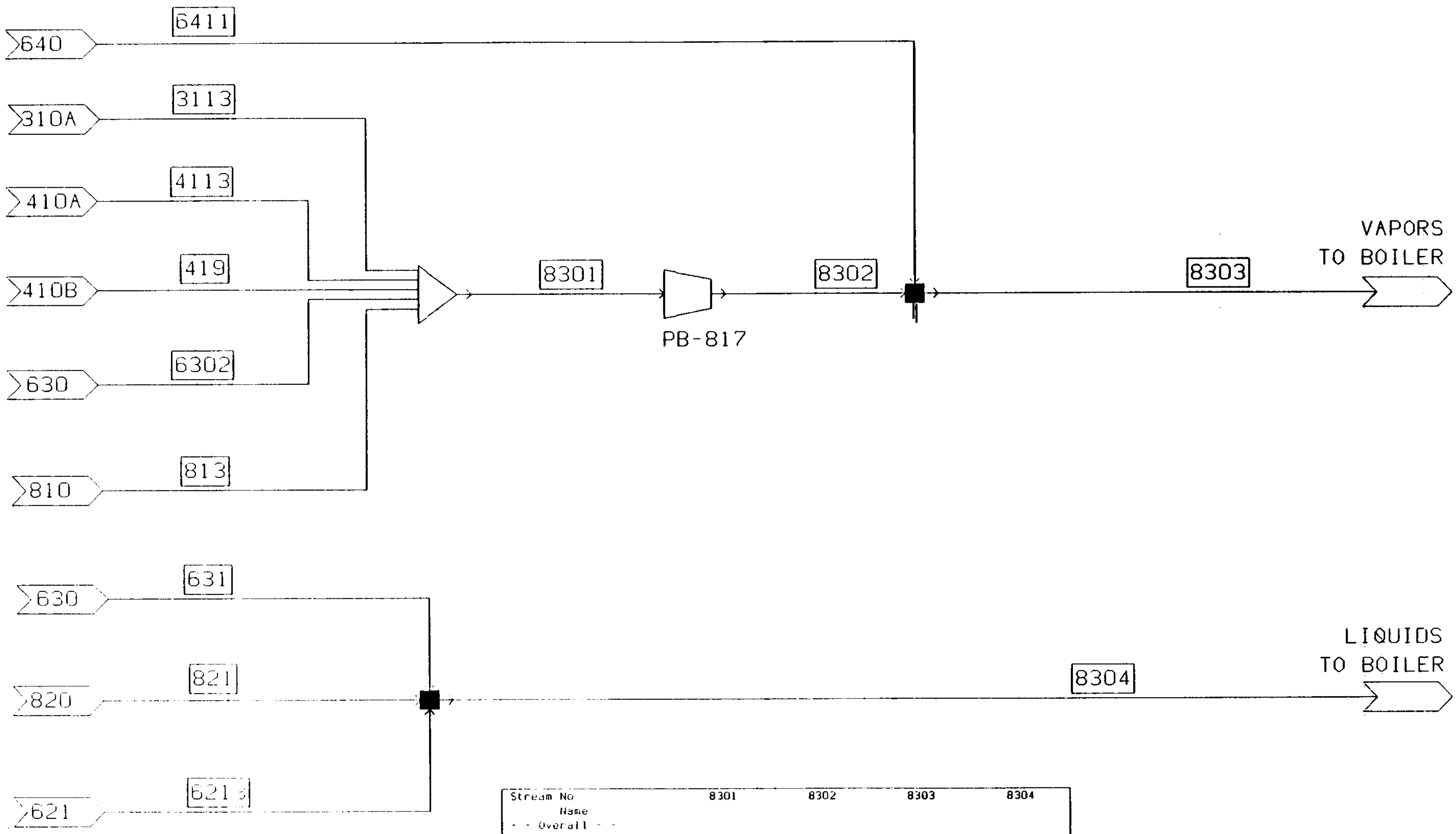
9. Area 900: Steam Boiler/Turbogenerator

A steam balance flowsheet for the steam circuit is included based on the system used in the Radian report(16). The turbogenerator uses 10,441 kpa (1,500 psig) steam at 510°C (950°F). Both medium pressure and low pressure steam are extracted to supply the process requirement. The remaining steam is sent to a condensing turbine to maximize the power generation. Efficiencies are assumed to range from 79 to almost 85 percent.



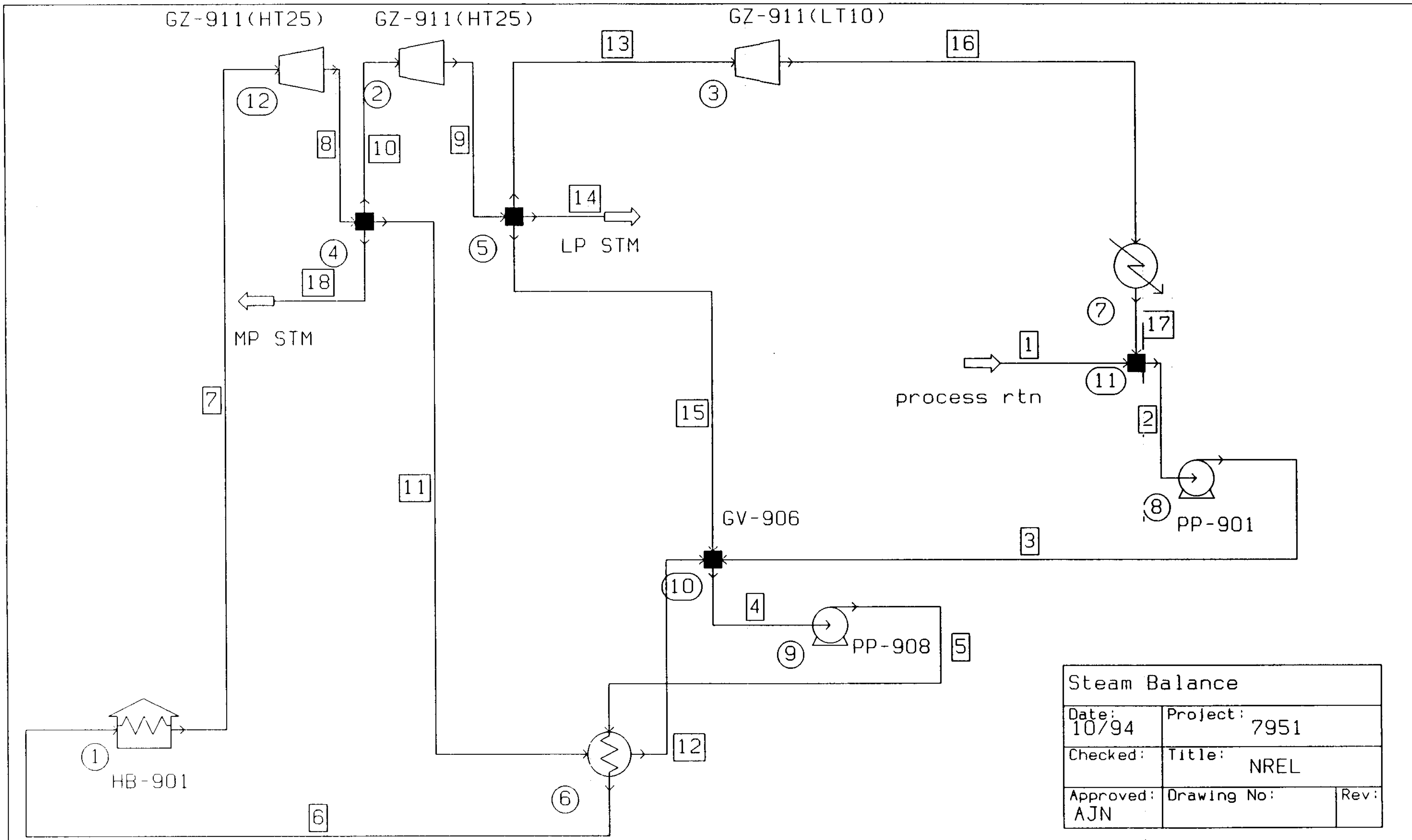
BESSF-820: WASTEWATER TREATMENT
AEROBIC BIOTREATMENT

Stream No	812	8201	8202	8203	8204	8205	8206	8207	8208	821	822
Name											
- - Overall - -											
Temp C	35.	20.	134.	35.	52.	52.	20.	20.	20.	20.	20.
Pres Pa	404000.	404000.	275000.	102000.	102000.	102000.	102000.	102000.	102000.	102000.	452000.



Stream No	8301	8302	8303	8304
Name				
- - Overall - -				
Temp C	32.	41.	40.	93.
Pres Pa	101000.	111000.	111300.	108000.

BESSF-821: BOILER FUELS



Stream No	1	2	3	4	5	6	7	18	11	14	15	16	12
Name	process rtn							MP STM		LP STM			
- - Overall - -													
Mass flow lb/h	343290.0000	414640.0312	414640.0312	497407.0000	497407.0000	497407.0000	497407.0000	256161.0000	44600.0000	87129.0000	38167.0000	71350.0234	44600.0000
Temp F	120.4368	120.4367	121.1817	222.3022	229.3380	314.1483	950.0001	460.1861	460.1861	318.6778	318.6778	120.4368	309.9000
Pres psia	1.7200	1.7200	145.0300	62.2300	1893.2000	1893.1990	1514.3989	171.3000	171.3000	66.9100	66.9100	1.7200	159.3300
Enth MMBtu/h	30.36	36.74	36.97	94.88	98.43	141.7	725.8	320.2	55.75	103.7	45.41	70.83	12.51

V EQUIPMENT SIZING

This section lists the design assumptions and bases used to specify equipment sizes.

- Tanks
- Agitators
- Pumps
- Heat exchangers
- Miscellaneous equipment
- Utilities

Equipment sizes can be found in Appendix V.

A. TANKS

Unless otherwise noted below, sizing criteria for tanks were the same used in the 1991 SERI report[5].

- T-201 Sulfuric Acid Storage Tank
  - Sized to hold 24 hours of sulfuric acid needed for normal operating conditions.

- T-203 Blowdown Tank
  - Sized for 5 minutes residence time.

- T-206 Neutralization Reaction Tank
  - Sized for 10 minutes residence time.

- T-220 Lime Slurry Tank
  - Sized for 24 hours hold of line slurry at normal operating conditions.

- T-321 Base Tank
  - Sized to hold 24 hours of liquid ammonia needed for normal operating conditions.

- T-601 Degasser Drum

- Sized for 5 minutes residence time.

- T-803 Equalization Tank
  - Sized for 24 hours hold.

- T-804 Anaerobic Reaction
  - Two tanks set at 425,000 gallons capacity.

T-804
Stream 806 in hr
in 126,321 kg/hr
= 278,558 lb/hr
= 33,398 gal/hr

- T-807 Biotreater
  - Four tanks set for total residence time of 3 days.

Res Time = $\frac{900{,}000 \text{ gal}}{33{,}398 \text{ gal/h}}$ = 26.9 = 27 h

The SERI report[5] indicates that the pH in the fermentation vessels (xylose and SSF) can be as low as 3.5. It is known that acidic solutions are highly corrosive to carbon steel, and even more so if carbon dioxide is present. Experience in the corn-to-ethanol industry has been primarily with stainless steel fermentation vessels.[5] However, stainless steel could increase the overall investment by approximately 20 percent.

A report by United Engineering[17] indicates that a lined carbon steel vessel would be less expensive than stainless steel by about 45 percent (750,00 gallons), but more expensive than carbon steel by about 40 percent. However, this latter cost is subject to a broad range of quotes depending upon the type of lining, as well as other variables. There are a broad range of linings available and locating a suitable coating for the fermentation vessels should not be a problem. The investment costs were based on the United Engineering report[17] for a lined carbon steel tank.

B. COLUMNS

The columns were rigorously sized using CHEMCAD data modelled with the following parameters:

- AS-601 Beer Still
  - Trays were one pass sieve trays, 1.9 cm diameter holes, to minimize plugging from solids.
  - Column diameter was limited to 4.1 m internal diameter, based on transportation restrictions.
- AS-602 Rectification Still
  - Trays use one-pass valve trays.
- AS-604 Vent Scrubber
  - Packed column using 1" pall rings, random packing.

For more detailed results of column sizing, please refer to Appendix A.III.

C. HEAT EXCHANGERS

Heat exchangers were sized based on the required heat exchange duty, with area calculated from:

$$A = \frac{Q}{U\Delta T_{LM}}$$

where

A = area of exchanger surface, m^2
U = heat transfer coefficient, W/m^2K
Q = heat duty, W
ΔT_{LM} = log mean temperature difference, K

Exchangers with liquid/liquid flow were assumed to be counter current flow designs.

The following heat transfer coefficients were used for exchanger sizing[5]:

	W/m^2K
Condensing steam - liquid	3,976
Liquid - liquid	1,278
Condensing vapors - gas	568
Condensing vapors - liquid	2,272
Coils in agitated tank	568
Gas - liquid	341

D. PUMPS

Pumps were sized based on an estimated pressure drop expected by the fluid, due to a combination of static head and dynamic head. Dynamic head estimates included possible control values (set at a minimum 70 kPa or 25 percent of dynamic head loss, whichever greater), and heat exchangers (70 kPa drop for liquid flows).

Please refer to Appendix A.IV (Equipment List) for detailed estimates on differential pressure for each pump and horsepower requirements for drivers.

E. MISCELLANEOUS EQUIPMENT

- MR-201/202 Prehydrolysis Reactor
  - This equipment was sized using data supplied by the manufacturer of the pilot plant reactor equipment.

- PSA Unit
  - Sized for supplying 1.5 times the theoretical oxygen demand of the wastewater treatment aerobic reactors.

- Wastewater Treatment Equipment
  - Please refer to the CH2M/Hill report[4], used as a basis for sizing the equipment in area 800, except for the anaerobic reactor where the loading rate was doubled.

- All OSBL (Area 900) Equipment
  - Sizing based on plant utility requirements (see Section F below).

F. UTILITIES

Three significant changes are noticeable in the new base case when compared to the SERI report. The most noticeable change is that the steam use in Section 600 (ethanol recovery) has increased significantly and the steam pressure has been upgraded to 1,034 kPa (150 psig). The amount required has increased because the columns as designed in the SERI report appear to be inadequate to meet the present needs. Attempts to model the SERI designed Beer Still (16 actual trays operating at a pressure of 15 psig and a reflux ratio of 0.4) using CHEMCAD showed that the column was incapable of meeting the overheads specifications.

Chem Systems redesigned the distillation section as two highly heat integrated columns as described above. The result is somewhat more steam being consumed (95 versus 78 thousand kilograms per hour), but since the SERI design was inadequate a comparison here is irrelevant. The higher pressure required by the first column (in order to be able to reboil the second column with the overheads from the first column) results in the low pressure steam being too cold to reboil the first column. Thus, the higher pressure steam is required as the heat source. The payout for the change to a high pressure beer still is 1.5 years on an additional $3.1 million investment.

The amount of cooling water consumption has decreased because of additional heat integration and the increased use of chilled water (in order to cool the recycle water for the seed fermenters). The fermentation air requirement has been decreased because the new design requires only one SSF seed train.

The utilities are summarized and compared to the SERI design in the appendix.

VI COST MODEL

A. COST ESTIMATE

1. Basis

(a) Purchased Equipment Costs

The basis for most of the purchased equipment cost is "Price and Delivery Quoting Service for Process Equipment Costs", a commercially available computer software program. Pricing for certain equipment which was not covered by this software was usually obtained through vendor quotes(e.g. lobe pumps, disk refiner, pre-hydrolysis system, circulating fluidized-bed boiler). In general a reasonableness check was made on most equipment by comparing the costs with in-house data for order-of-magnitude accuracy. All pricing is for 1993.

The inside battery limits (ISBL) portion of the plant can be thought of as a boundary over which are imported raw materials, catalyst and chemicals, and utility supply streams. In a like manner, main products, by-products and spent utility return streams are exported over the boundary.

The battery limits investment includes the cost of the main processing blocks of the chemical plant necessary to manufacture products. It represents a plant ordered from a contractor and built on a prepared site with normal load-bearing and drainage characteristics in a developed part of the world (in this case, the southeast United States).

Battery limits investment includes the installed cost of the following items:

- Process equipment vessels and internals, heat exchanges, pumps and compressors, drivers, solids handling, etc.
- Major spare equipment/parts (e.g., spare rotor for turbine or compressor,etc.)
- Buildings housing process units

- Process and utility piping and supports within the major process areas
- Instrumentation, including computer control systems
- Electrical wiring and hardware
- Foundations and pads
- Structures and platforms
- Insulation
- Paint and corrosion protection
- Process sewers
- Fire water piping and monitors
- Utility stations

Offsites or OSBL include the plant investment items that are required in addition to the main process units within the battery limits. These auxiliary items are necessary to the functioning of the production unit, but perform in a supporting role rather than being directly involved in the production.

In estimating some of the offsite costs Chem Systems has used factors based on Chem Systems' previous experience with different projects over the past several years. These items are described in detail below along with the factor (as a percentage of ISBL) used to determine the cost.

- Buildings (4%) - This includes an office and administrative building, laboratory, change house and cafeteria, guard house, garage, maintenance shop and warehouse.
- Site development (9%) - Included in the site development costs are fencing, curbing, parking lot, roads, wells, drainage, rail system, soil borings and general

paving. The above factor allows for minimum site development assuming a clear site, no unusual problems such as right-of-ways, difficult land clearing or unusual environmental problems (these are covered under other projects below).

- Additional piping (4.5) - This includes piping required for a flare system, instrument and plant air, process water, fire water loop, inert gas, process area tie-ins and interconnecting piping within the storage area.

(b) Erection Costs

Multipliers have been developed whereby the installed cost of various kinds of equipment may be found.[15] Such multipliers range from 1.2 to 3.0 and have been applied to each individual piece of equipment in order to come up with the total erected cost (TEC). The appropriate multipliers are shown in Table VI.A.1.

TABLE VI.A.1
MULTIPLIERS FOR INSTALLATION COST OF PROCESS EQUIPMENT

Equipment		Multiplier[1]
Agitators	- carbon steel (cs)	1.3
	- stainless steel (ss)	1.2
Boilers		1.3
Compressors (motor driven)		1.3
Cooling towers		1.2
Distillation columns	- cs	3.0
	- ss	2.1
Filters		1.4
Heat exchangers (S&T)	- cs/ss	2.1
Pumps - lobe		1.4
- centrifugal,	- cs	2.8
- centrifugal,	- ss	2.0
Pressure vessels	- cs	2.8
	- ss	1.7
Tanks (field erected)	- cs	1.4
	- cs w/lining	1.6
	- ss	1.2
Solids handling equipment		1.2-1.4
Turbogenerator		1.5

[1] Installed cost = (purchase equipment cost) (multiplier)

(c) Indirect Costs

The indirect component of the plant construction costs is based on Chem Systems' experience. The components of the indirects are described below along with the factors (as a percentage of TEC) applied for this cost estimate.

- Prorateable costs (10%) - This includes fringe benefits, burdens and insurance of the construction contractor.
- Field expenses (10%) - This includes consumables, small tool equipment rental, field services, temporary construction facilities and field construction supervision.
- Home office construction and fee (25%) - This includes engineering plus incidentals, purchasing and construction.
- Project contingency (3%) - Because of the length of the equipment list, a small process contingency of 3 percent has been included.

(d) Other Project Costs

In addition to the equipment costs, erection costs and indirects there are other costs associated with any project that mst be paid by the owner. These costs are summarized below for a typical project and typically range from 10 to 30 percent of the total investment (ISBL + OSBL) costs. These costs are very site and project specific. For this project Chem Systems has utilized a relatively low value of 10 percent. Other project costs include items such as:

- Start-up and commissioning costs (extra operating manpower; owner's technical manpower; start-up services such as licensor representatives, contractor personnel and equipment supplier and other vendor representatives; operating manuals and training programs; modification and maintenance during start-up; and operating expenses to the extent that they do not result in salable product).
- Land, rights-of-way, permits, surveys, and fees
- Piling, soil compaction/dewatering, unusual foundation requirements

- Sales, use and other taxes
- Freight, insurance in transit and import duties on equipment, piping, steel, instrumentation, etc.
- Overtime pay during construction
- Field insurance
- Project team - including preliminary planning studies, HAZOP studies, environmental reviews, design, engineering, estimating, inspection, accounting, auditing, legal, construction management, travel and living
- Initial charges of raw materials, catalysts, chemicals, and packaging materials
- Initial stock of maintenance, laboratory, operating and office supplies
- Transportation equipment - including barges, railcars, tank trucks, bulk shipping containers, plant vehicles, etc.
- Provisions for temporary shutdown expenses
- Owner's scope contingency allowance (5 percent assumed)
- Escalation or inflation of costs over time
- Interest on construction loan
- 100 percent equity, no financing charges included

2. Results

The capital investment is provided in Appendix V and summarized in Table IV.A.2. At this level of detail the capital cost estimate is judged to have an accuracy of plus or minus 25 percent. The purchased equipment for the ISBL totals $25 MM and the corresponding installed cost is estimated to be $40 MM. The major investment in this area is the SSF facilities having an installed cost of over $17 MM. In the off-site area the major investment item is the boiler package (boiler, BFW system and bag house) which is estimated to cost about $26.6 MM (installed). The total installed plant cost (both ISBL and OSBL) is estimated to be $101 MM. Adding in the indirects to this total gives a total capital investment of $150 MM. The total project investment including the owner's other project costs is estimated to be $165 MM

TABLE VI.A.2
INVESTMENT COST SUMMARY - BIOMASS TO ETHANOL PLANT
(millions dollars, 1993 basis)

Plant Area		Purchased Equipment	Installed Equipment	
ISBL				
100	Wood handling	2.48	3.20	1.18
200	Prehydrolysis	5.19	7.75	19.1
300	Xylose fermentation	2.28	3.19	
400	Cellulase production	1.20	1.74	10
500	SSF	11.37	17.68	14
600	Ethanol recovery	2.93	6.49	4.4
	Total	**25.43**	**40.05**	
OSBL				
700	Off-site tankage	1.39	2.12	2.7
800	Waste treatment	4.44	6.09	7.7
900	Utilities			
	Boiler package (including BFW system)	20.28	26.61	25.3
	Process water	0.21	0.45	1.1
	Turbogenerator	6.12	9.19	
	Cooling water package	2.56	3.08	138
	Chilled water package	1.02	1.23	
	Plant, instrument and fermentation air	4.38	5.33	
	CIP/CS	0.17	0.30	
	Buildings		1.60	
	Site development		3.60	
	Additional piping		1.80	
	Total	**40.58**	**61.38**	
Indirects				
Prorateable costs			10.14	
Field expenses			10.14	
Home office construction and fees			25.36	
Contingency			3.04	
Total capital investment			150.12	
Owner's costs			15.01	
Total project investment			**165.13**	

B. COST ALGORITHMS

As part of developing an integrated, flexible model for this project, Chem Systems has developed cost algorithms that generate equipment cost estimates as a function of material balance flows (e.g. vessel size and, thus, cost as a function of a stream volumetric flow). These were then used to estimate the total investment cost.

The algorithms take the form:

$$\log (\text{F.O.B.}) = a \log (X) + b$$

where X is the stream variable (e.g. SCFM for a compressor) or equipment variable (e.g. square feet for a heat exchanger). Thus, by linking the process simulator output to a spreadsheet containing the algorithms, changes and sensitivities can be run and a new cost estimate obtained relatively easily and quickly, with only a few manual inputs.

C. COST OF PRODUCTION

A detailed estimate of the production costs can be separated into two discrete categories:

- Variable costs - Raw material (wood) including catalyst and chemicals; by-products (solids for disposal); and utilities (purchased electricity and raw water).

- Fixed costs - Direct operating costs (labor, maintenance, and direct overheads) and allocated costs (general plant overheads, insurance and property taxes).

The following factors have been used to estimate the fixed costs and are based on Chem Systems' past experience:

- Direct overheads associated with the workforce are on average about 45 percent of direct labor costs in the United States.

- Maintenance costs are typically between 2 and 4 percent of investment (3 percent has been applied)

- General administration costs are generally 65 percent of labor and maintenance costs in the United States

- Taxes and insurance typically range from 0.5 to 1.5 percent of the investment (0.7 percent has been used).

The annual capital charges are 20 percent of the total investment. This charge is approximately equivalent to a 10 percent discounted cash flow rate of return with the following parameters:

Material pricing used in the cost of production estimate are shown in Table VI.C.1.

Utility consumption by area is given in Appendix IV and compared with the 1991 SERF values.

TABLE VI.C.1
PRICING BASIS
(dollars per metric ton, fourth quarter 1993)

Wood (dry)	46
Sulfuric acid	72
Lime	50
Ammonia	129
Corn steep liquor	243
Nutrients	273
Antifoam	573
Glucose	1,168
Gasoline	165
Diesel	156
Solids disposal	(20)
Catalyst and chemicals	6

The cost of production estimate is shown in Table VI.C.2. The net raw materials is estimated to be $208 per metric ton (62 cents per gallon). Utilities are estimated to provide a credit of about $33 per metric ton (10 cents per gallon). The total variable cost is $176 per metric ton (52 cents per gallon).

Adding in the direct fixed costs ($27 per metric ton) and allocated fixed costs ($21/per metric ton) gives a total cash cost of production of $222 per metric ton or 66 cents per gallon.

Adding in the annual capital charge (20 percent of total investment) almost doubles the production cost. The resulting cost of denatured ethanol is estimated to be $430 per metric ton or $1.27 per gallon.

TABLE VI.C.2
COST OF PRODUCTION ESTIMATE FOR:ETHANOL
PROCESS:BIOMASS PER CSI

			CAPITAL COST	MILLION U.S. $
Plant start-up	4Q93		ISBL	59.3
Analysis date	4Q93		OSBL	90.8
Location	SE US		Total Plant Capital	150.1
Capacity	159.3 Thousand MT/yr		Other Project Costs	15.0
	54.0 Millions gallons per year		Total Capital Investment	165.1
Operating rate	100 percent		Working capital	11.4
Throughput	159.3 Thousand MT/yr			

PRODUCTION COST SUMMARY			UNITS Per MT Product	PRICE U.S. $ /Unit	U.S. $ Per MT	ANNUAL COST MM U.S. $	U.S. $ Per Gal
RAW MATERIALS	Wood (dry), MT		3.4613	46	160.244	25.53	
	Sulfuric Acid, MT		0.0551	72	3.947	0.63	
	Lime, MT		0.0416	50	2.063	0.33	
	Ammonia, MT		0.0374	129	4.829	0.77	
	Corn steep liquor, MT		0.0095	243	2.304	0.37	
	Nutrients, MT		0.0215	273	5.868	0.93	
	Antifoam, MT		0.0006	573	0.344	0.05	
	Glucose, MT		0.0083	1,168	9.698	1.55	
	Gasoline, MT		0.0500	165	8.245	1.31	
	Diesel, MT		0.0135	156	2.108	0.34	
	Catalyst & Chemicals			6	5.512	0.88	
	TOTAL RAW MATERIALS				**205.163**	**32.69**	**0.61**
BY-PRODUCT CREDITS	Solids Disposal, MT		0.15635	(20)	3.127	0.50	
	TOTAL BY-PRODUCT CREDITS				**3.127**	**0.50**	**0.01**
NET RAW MATERIALS					**208.290**	**33.19**	**0.62**
UTILITIES	Purchased Power, MWH		-0.81992	42	(34.437)	(5.49)	
	Raw water, MT		30.99803	0	0.819	0.13	
	TOTAL UTILITIES				**(33.617)**	**(5.36)**	**(0.10)**
VARIABLE COST					**174.672**	**27.83**	**0.52**
DIRECT FIXED COSTS	Labor, 41 Men	32.70 Thousand U.S. $			8.415	1.34	
	Foremen, 9 Men	37.10 Thousand U.S. $			2.096	0.33	
	Super., 1 Men	44.80 Thousand U.S. $			0.281	0.04	
	Maint., Material & Labor	3.00 % of ISBL			11.161	1.78	
	Direct Overhead	45 % Labor & Supervision			4.856	0.77	
	TOTAL DIRECT FIXED COSTS				**26.809**	**4.27**	**0.08**
ALLOCATED FIXED COSTS	General Plant Overhead	65 % Labor & Maintenance			14.269	2.27	
	Insurance, Property Tax	0.7 % Total Plant Capital			6.595	1.05	
	TOTAL ALLOCATED FIXED COSTS				**20.864**	**3.32**	**0.06**
TOTAL CASH COST					**222.345**	**35.43**	**0.66**
Annual Capital Charge		20 % total capital investment			207.281	33.03	
Cost of denatured ethanol					**429.626**	**68.45**	**1.27**

VII SENSITIVITY ANALYSIS

A. BASIS

The report prepared in 1991 by SERI[5] examined numerous parameters and their influence on the biomass process. In order to approach the target of 67 cents per gallon, several improvements were combined within one sensitivity. The basis for this sensitivity analysis is shown in Table VII.A.1 with the corresponding base case parameter.

TABLE VII.A.1
PROCESS PARAMETERS AND ASSUMPTIONS

	Base Case	Sensitivity (goal)
Cellulose to ethanol yield, %	75.7	90
Xylose to ethanol yield, %	85.5	95
Xylan to xylose yield, %	80.0	90
SSF fermentation time, days	7	3
Xylose fermentation time, days	2	1
Ethanol concentration in SSF, %	4.17	6
Cellulase loading, IU/g	7	3
SSF and xylose seed fermentations	yes	eliminated
Feedstock cost, $/dry ton (short)	42	34
Feedstock carbohydrate content, %	70.2	77.2
On-stream time, %	91.3	98
Electricity selling price, cents/KWH	4.2	6
Ethanol purification	distillation	mole seive

The changes to the base case can be grouped into three categories: technology improvements (yields, fermentation times, equipment, concentrations, loading, etc.); feedstock production improvements (cost and content); and more optimistic cost of production factors (electricity selling price and onstream time).

B. FLOW SCHEME

The flow scheme remains essentially unchanged except for the elimination of the SSF and xylose seed fermentation and the changes to the distillation section.

The distillation section has been simplified by the addition of a mole seive unit (replaces the rectification column). The objective is to reduce the investment costs, as well as the operating cost of the distillation columns. Although several mole seive units are currently being developed for this application including concentration and temperature swing operation, the pressure swing adsorption (PSA) operation designed by Delta T Corp. (Williamsburg, Virginia) is already commercial (model TSX-44) and claims to meet both requirements of lower investment and operating costs. (In reality the difference in investment is negligible).

The design operates in the vapor phase which requires that the ethanol be vaporized and condensed afterwards, but heat integration between the feed and effluent will minimize the need for external energy sources. At a minimum, two mole sieve vessels are required: one in normal service and one being regenerated.

Currently the largest commercial unit is about half the capacity of the unit required by the NREL plant. However, this does not appear to be a limitation with the Delta-T proprietary fluiddynamic technique for guaranteeing uniform flow through the beds.

Chem Systems has assumed that the simplier distillation system (one column plus PSA units) will require one less operator per shift.

C. RESULTS OF SENSITIVITY ANALYSIS

The sensitivity analysis results can be found in Appendix VIII and are discussed below.

1. Investment

The investment has been reduced significantly for the sensitivity case. The ISBL investment has been reduced by 30 percent. The major contributor to this savings is the reduction in the number of SSF and xylose fermentation tanks, as well as the elimination of the SSF and xylose seed fermentation tanks.

The OSBL investment is lower than the base case by about 5 percent. The larger turbogenerator is the result of a lower process steam requirement with the use of the PSA system for ethanol recovery and, thus, more power generation. This somewhat offsets the savings in the cooling water and fermentation air sections.

The overall investment results is a savings of $25 million in the total capital investment or about 15 percent less than the base case.

2. Operating Costs

The production of ethanol has increased by 30 percent over the base case to 71 million gallons per year, a portion of which is due to more onstream time and the rest due to better yields. The utilities have decreased by as much as 46 percent (fermentation air) from the base case. On a unit consumption per kilogram of ethanol basis, the improvement in utility consumption ranges from 23 to 59 percent.

An estimate of the cost of production (see Table VII.C.1) shows that the cost has been lowered from $430 per metric ton ($1.27 per gallon) to $251 per metric ton (74 cents per gallon). (Note that the COP spreadsheet is based on 8,000 hours per year. Thus, to achieve an operating rate of 98 percent (8.585 hours), the COP shows an operating rate of 107 percent). The savings from the base case are in four areas. Raw materials show a lower cost of $68.5 per metric ton (20 cents per gallon) mostly due to the lower cost assumed for the wood feedstock. The higher electrical production makes up most of the additional utility saving of $15.5 per metric ton (5 cents per gallon). The fixed costs show a reduction of $20.5 per metric ton (6 cents per gallon) due mostly to the higher production rate. However, the largest savings ($73.5 per metric ton or 22 cents per

TABLE VII.C.1
COST OF PRODUCTION ESTIMATE FOR:ETHANOL
PROCESS:BIOMASS PER CSI – SENSITIVITY CASE

			CAPITAL COST	MILLION U.S. $
Plant start-up	4Q93		ISBL	41.2
Analysis date	4Q93		OSBL	86.6
Location	SE US		Total Plant Capital	127.8
Capacity	210.5	Thousand MT/yr	Other Project Costs	12.8
	71.3	Millions gallons per year	Total Capital Investment	140.5
Operating rate	107	percent	Working capital	8.5
Throughput	225.9	Thousand MT/yr		

PRODUCTION COST SUMMARY		UNITS Per MT Product	PRICE U.S. $ /Unit	U.S. $ Per MT	ANNUAL COST MM U.S. $	U.S. $ Per Gal
RAW MATERIALS	Wood (dry), MT	2.6201	37	98.196	22.18	
	Sulfuric Acid, MT	0.0417	72	2.988	0.67	
	Lime, MT	0.0315	50	1.562	0.35	
	Ammonia, MT	0.0283	129	3.656	0.83	
	Corn steep liquor, MT	0.0095	243	2.304	0.52	
	Nutrients, MT	0.0162	273	4.442	1.00	
	Antifoam, MT	0.0006	573	0.344	0.08	
	Glucose, MT	0.0083	1,168	9.698	2.19	
	Gasoline, MT	0.0500	165	8.245	1.86	
	Diesel, MT	0.0102	156	1.596	0.36	
	Catalyst & Chemicals		6	5.512	1.24	
	TOTAL RAW MATERIALS			**138.541**	**31.29**	**0.41**
BY-PRODUCT CREDITS	Solids Disposal, MT	0.06254	(20)	1.251	0.28	
	TOTAL BY-PRODUCT CREDITS			**1.251**	**0.28**	**0.00**
NET RAW MATERIALS				**139.792**	**31.57**	**0.41**
UTILITIES	Purchased Power, MWH	−0.83059	60	(49.835)	(11.26)	
	Raw water, MT	25.47079	0	0.673	0.15	
	TOTAL UTILITIES			**(49.162)**	**(11.10)**	**(0.15)**
VARIABLE COST				**90.630**	**20.47**	**0.27**

					U.S. $ Per MT	ANNUAL COST MM U.S. $	U.S. $ Per Gal
DIRECT FIXED COSTS	Labor,	36 Men	32.70 Thousand	U.S. $	5.212	1.18	
	Foremen,	8 Men	37.10 Thousand	U.S. $	1.314	0.30	
	Super.,	1 Men	44.80 Thousand	U.S. $	0.198	0.04	
	Maint., Material & Labor		3.00 % of ISBL		5.467	1.23	
	Direct Overhead		45 % Labor & Supervision		3.026	0.68	
	TOTAL DIRECT FIXED COSTS				**15.217**	**3.44**	**0.04**
ALLOCATED FIXED COSTS	General Plant Overhead		65 % Labor & Maintenance		7.924	1.79	
	Insurance, Property Tax		0.7 % Total Plant Capital		3.959	0.89	
	TOTAL ALLOCATED FIXED COSTS				**11.884**	**2.68**	**0.04**
TOTAL CASH COST					**117.731**	**26.59**	**0.35**
Annual Capital Charge			20 % total capital investment		133.532	28.11	
Cost of denatured ethanol					**251.263**	**54.70**	**0.74**

gallon) is in the lower annual capital charge which is a direct result of the lower investment.

Included in the appendix are a comparison of the utilities from the base case and the sensitivity case, as well as the investment summary for the sensitivity case.

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CHEM SYSTEMS

FAX COVER SHEET

FROM 914 631 8851

Date:	April 22, 1994
Fax No:	303-231-1352
Company:	**NREL**
To:	Vicky Putsche
From:	Alan J. Nizamoff
Pages to Follow:	11

CC: DFB

Engineering Reports Used in the most Recent Analysis

Message:

In answer to Cindy's FAX dated April 21, 1994, we can supply the following:

1. I am sending the tray by tray liquid and vapor composition profiles under separate cover.

2. The presence of oxygen as a byproduct of anaerobic biotreatment is required in order to close the material balance. With the several components (namely glycerol, acetaldehyde, fusel oils, cellulase and soluble solids) there is an oxygen excess which unless accounted for in the reaction stoichiometry will result in an open material balance, preventing the simulator from converging.

   In the anaerobic treatment of wastewater, there are two distinct steps occurring. The primary stage is the degradation of higher organics to primary organic acids, namely acetic, propionic and n-butyric acid. A multitude of mixed bacteria are responsible for this first and fastest step. The final step is methanation, where purely anaerobic bacteria convert the organic acids into methane, carbon dioxide and short organic acids.

   Chem Systems was not supplied with any data on acid production within the anaerobic area. However, NREL supplied the assumption that only biogass was a product of the degradation, implying a methanation efficiency of 100 percent. The results in the need to account for excess oxygen in the feed in methods other than dissolved acids.

Admin. Assist.: LTM

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303 South Broadway Tarrytown NY 10591-5487
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Fax to Vicky Putsche
4/22/94

While it is agreed, in general, that oxygen production is minimal, unless production conversions to acetic and longer-chain acids can be provided, the fastest solution is to account for excess oxygen as molecular. Until better data can be supplied for the acidulation step and methanation conversion efficiency, this is necessary to complete the component material balance.

3. Decreasing the residence time in the anaerobic digestors was based on information Cindy provided in our meeting on March 9th.

4. FAX to Cindy Riley dated April 1, 1994, contained this information, as well as our most recent estimate of the cost of production. I have attached a copy herein.

5. A more detailed explanation is provided below for the specific items Cindy mentioned in her FAX.

   1) buildings

   This includes an office and administrative building, laboratory, change house and cafeteria, guard house, garage, maintenance shop and warehouse.

   2) site development

   Included in the site development costs are fencing, curbing, parking lot, roads, wells, drainage, rail system, soil borings and general pavings. The above factor allows for minimum site development assuming a clear site, no unusual problems such as right of ways, difficult land clearing or unusual environmental problems. (Since we expect that the Ethanol facilities will be located in a treed area as opposed to a cleared site, we employed the maximum value as noted below.)

   3) additional piping

   This includes piping required for a flare system, instrument and plant air, process water, fire water loop, inert gas, process area tie-ins and interconnecting piping within the storage area.

   4) prorateable costs

   This includes fringe benefits, burdens, and insurance.

CHEM SYSTEMS

Fax to Vicky Putsche
4/22/94

5) field expenses

This includes consumables, small tool equipment rental, field services, temporary construction facilities, and field construction supervision.

6) home office construction and fee

This includes engineering plus incidentals, purchasing, and construction management.

The values used for the NREL cost estimate are based on Chem Systems' previous experience with different projects over the past several years. The ranges and values used for this project are presented below:

	Percentage of ISBL		
	Min	Max	Value Used
buildings	3	5	4
site development	3	9	9
additional piping	3	6	4.5
prorateable costs	4	11	10
field expenses	5	13	10
home office const. and fee	15	30	25

Please let me know if we can be of further assistance. We look forward to the results of your review by May 13.

Regards,

Alan Nizamoff

To: Vicky Putsche

CHEM SYSTEMS

FAX COVER SHEET

FROM 914 631 8851

Date:	April 1, 1994
Fax No:	303-231-1352
Company:	**NREL**
To:	Cynthia Riley **CC:** DFB
From:	Alan J. Nizamoff
Pages to Follow:	Eight (8)

Message:

Attached are the capital estimates and cost of production estimates corresponding to the re-engineered base case material balance sent to you in March. We have incorporated all vendor quotes in this latest estimate, as well as adjusted other items per our meeting on March 9 (e.g., wastewater treatment residence times). We are waiting for your endorsement of these results before proceeding with the sensitivity cases.

Admin. Assist.: Gina L. Resta

Chem Systems Inc
303 South Broadway Tarrytown NY 10591-5487
Telephone: (914) 631-2828 Telex: 221844 Facsimile: (914) 631-8851

EQUIPMENT COST BY SECTION

PLANT AREA	1990 NREL	Chem Systems BASE EQUIPMENT COST ($ MM)	INSTALLED EQUIPMENT COST ($ MM)
ISBL			
100 WOOD HANDLING	2.51	2.48	3.20
200 PREHYDROLYSIS	8.31	5.17	7.72
300 XYLOSE FERMENTATION	2.16	2.36	3.28
400 CELLULASE PRODUCTION	0.97	1.02	1.47
500 SSF	7.36	10.86	16.79
600 ETHANOL RECOVERY	1.45	2.34	5.07
Total		**$\boxed{24.22}$**	**37.54**
OSBL			
700 OFF-SITE TANKAGE	1.44	1.34	2.04
800 WASTE TREATMENT	1.39	11.90	15.24
900 UTILITIES			
Boiler Feed Water and Boiler Package	21.1	20.64	30.94
Process Water	0.32	0.21	0.45
Turbogenerator	6.50	9.88	14.82
Cooling Water	0.92 Field erected	2.60	3.39
Chilled Water Package	0.60	2.79	3.35
Plant and Fermentation Air	1.82	4.58	5.58
CIP/CS		0.17	0.30
BUILDINGS			1.50
SITE DEVELOPMENT			3.38
ADDITIONAL PIPING			1.69
Total		**54.11**	**82.66**
Total Equipment Cost		**78.33**	**120.20**
Proratable Costs			12.02
Field Expenses			12.02
Home Office Construction and Fee			30.05
Contingency			12.02
Total Fixed Capital Investment			**186.31**
Owner's Cost			18.63
Total Capital Investment			**204.94**

Installation Factor = $\frac{186.31}{78.33} = 2.38$

$\frac{186.31}{57.09} = 3.23$

EQUIPMENT COST BY SECTION

SERI VS. CHEM SYSTEMS

	PLANT AREA	SERI BASE EQUIPMENT COST ($ MM)	*Chem Systems* BASE EQUIPMENT COST ($ MM)
ISBL			
100	WOOD HANDLING	2.51	2.48
200	PREHYDROLYSIS	8.31	5.17
300	XYLOSE FERMENTATION	2.16	2.36
400	CELLULASE PRODUCTION	0.97	1.02
500	SSF	7.36	10.86
600	ETHANOL RECOVERY	1.4	2.34
	Total	**22.71**	**24.22**
OSBL			
700	OFF-SITE TANKAGE	1.44	1.34
800	WASTE TREATMENT	1.39	11.90
900	UTILITIES	11.68	21.52
	BOILER PACKAGE (Installed)	19.82	29.03
	MISCELLANEOUS	2.52	6.57
	Total	**36.85**	**70.36**
	Total Equipment Cost w/ Boiler Installed	**59.56**	**94.58**

OUTPUT BY SECTION

PLANT AREA		*Chem Systems* BASE EQUIPMENT COST ($)	INSTALLED EQUIPMENT COST ($)
100	**WOOD HANDLING**		
pp-101	Flume	9,703	13,584
GS-103	Magnetic Chip Cleaner	10,882	13,058
GM-101A/B/S	Front End Loaders	412,152	494,582
GS-101	Radial Stacking Conveyor	131,984	184,777
GS-102	Belt Conveyer	202,589	283,624
GS-104	Milled Chip Belt Conveyor	42,272	59,181
GY-101A/B/C/D	Wood Chip Unloader with Scale	166,594	199,913
GG-101A/B/C/D	Disk Refiner	1,500,000	1,950,000
	TOTAL($ MM)	**2.48**	**3.20**
200	**PREHYDROLYSIS**		
GS-223	Lime Unloading Conveyor	19,022	26,631
T-201	Sulfuric Acid Storage	45,371	54,445
T-203	Blowdown Tank	36,337	43,605
T-206	Neutralization Reaction Tank	62,046	74,455
T-220*	Lime Slurry Tank	35,314	42,377
pp-201	Sulfuric Acid	3,900	7,799
pp-202	Hydrolyzate	65,037	91,052
pp-203A/S	Neutralized Hydrolyzate	104,285	145,999
pp-221*	Slurry Metering Pump	7,109	9,953
TT-220	Feed Cooler	121,464	255,074
GA-201	Line Mixer	222	266
GA-203	Blowdown Tank Agitator	19,629	23,555
GA-213	Neutralization Tank Agitator	28,746	34,495
GF-201	Desiccant Air Filter	1,057	1,480
MR-201/MR-202	Pre-Hydrolysis System (w/ plug screw feeder)	4,560,000	6,840,000
GS-226*	Rail Car weigh station	60,000	72,000
	TOTAL ($ MM)	**5.17**	**7.72**
300	**XYLOSE FERMENTATION**		
	Seed Fermenters		
FM-305/10	Xylose Seed Fermenter	100,698	140,978
FM-305/10	Xylose Seed Fermenter	35,530	49,742
FM-305/10	Xylose Seed Fermenter	13,371	30,752
FM-305/10	Xylose Seed Fermenter	4,377	10,066
FM-305/10	Xylose Seed Fermenter	1,433	3,295
FM-305/10	Xylose Seed Fermenter	469	1,079
	Total ($ MM)	**0.16**	**0.24**
FM-303	**Xylose Fermenters**	**1.47**	**2.06**
	Remaining Equipment		
T-301	Seed Hold Tank	100,698	140,978
T-321	Base Tank	14,186	39,722
pp-303*	Xylose Fermenter Product Pump	94,502	132,303
TT-301A*	Water Cooler	30,544	64,143
COILS	Xylose Fermentation Coils	15,089	37,722
COILS	Xylose Seed Fermentation Coils	2,011	5,027
GA-301	Seed Hold Tank Agitator	31,529	37,834
GA-303A-H	Xylose Fermenter Agitator	360,915	433,098
GA-305	First Seed Vessel Agitator	44,456	53,347
GA-306	Second Seed Vessel Agitator	28,304	33,965
GA-307	Third Seed Vessel Agitator	9,069	10,883
GA-308	Fourth Seed Vessel Agitator	3,824	4,589
	Total ($ MM)	**0.74**	**0.99**
	TOTAL ($ MM)	**2.36**	**3.28**

OUTPUT BY SECTION

PLANT AREA		*Chem Systems* BASE EQUIPMENT COST ($)	INSTALLED EQUIPMENT COST ($)
400	**CELLULASE PRODUCTION**		
	Seed Fermenters		
FM-401/4	Cellulase Seed Fermenter	68,696	96,174
FM-401/4	Cellulase Seed Fermenter	17,261	25,891
FM-401/4	Cellulase Seed Fermenter	3,570	5,356
FM-401/4	Cellulase Seed Fermenter	739	1,108
	Total ($ MM)	**0.09**	**0.13**
FM-400	**Cellulase Fermenter ($ MM)**	**0.25**	**0.41**
	Remaining Equipment		
T-400	Media Prep Tank	8,490	19,526
T-403A/B	Antifoam Tank	7,454	17,143
T-405	Sterile Feed Tank	76,014	106,420
T-410A/B	Cellulase Hold Tank	114,401	183,042
pp-401A/S	Feed	43,470	60,858
pp-403A/S	Fermenter Recycle	69,790	97,706
pp-411A/S	Prep Tank	2,416	6,764
pp-412	Cellulase Feed	13,096	18,334
TT-401A*	Water Cooler	321	673
TT-401B*	Water Cooler	78	163
TT-402A	Water Cooler	15,097	31,703
TT-402B*	Water Cooler	3,698	7,765
COILS	Cellulase Fermentation Coils	4,651	11,627
COILS	Cellulase Seed Fermentation Coils	29	73
GA-400	Prep Tank Agitator	5,483	6,580
GA-401A/B/C	Fermenter Agitator	127,403	152,884
GA-405	Feed Tank Agitator	63,175	75,810
GA-410	Hold Tank Agitator	48,715	58,457
GA-411	First Seed Vessel Agitator	53,231	63,878
GA-412	Second Seed Vessel Agitator	13,204	15,845
GA-413	Third Seed Vessel Agitator	4,294	5,152
	Total ($ MM)	**0.67**	**0.94**
	TOTAL ($ MM)	**1.02**	**1.47**
500	**SSF**		
	Seed Fermenters		
FM-501/6	SSF Seed Fermenter (S.c.)	242,888	388,620
FM-501/6	SSF Seed Fermenter (S.c.)	68,298	109,277
FM-501/6	SSF Seed Fermenter (S.c.)	25,966	59,723
FM-501/6	SSF Seed Fermenter (S.c.)	8,706	13,059
FM-501/6	SSF Seed Fermenter (S.c.)	2,593	3,890
FM-501/6	SSF Seed Fermenter (S.c.)	772	1,159
	Total ($ MM)	**0.35**	**0.58**
FM-500	**SSF Fermenter ($ MM)**	**8.57**	**13.71**
	Remaining Equipment		
T-501A	Seed Hold Tank (S.c.)	242,888	388,620
pp-501*	SSF Seed Transfer Pump	57,908	81,072
pp-505	Beer Transfer	230,252	322,353
COILS	SSF Fermentation Coils	14,146	35,366
COILS	SSF Seed Fermentation Coils	2,590	6,476
GA-500A-AA	SSF Fermenter Agitator	1,263,201	1,515,842
GA-501A	Seed Hold Tank Agitator (S.c.)	39,859	47,831
GA-510A	First Seed Vessel Agitator (S.c.)	56,202	67,443
GA-511A	Second Seed Vessel Agitator (S.c.)	23,700	28,440
GA-512A	Third Seed Vessel Agitator (S.c.)	7,594	9,113
GA-513A	Fourth Seed Vessel Agitator (S.c.)	3,202	3,843
	Total ($ MM)	**1.94**	**2.61**
	TOTAL ($ MM)	**10.86**	**16.79**

OUTPUT BY SECTION

PLANT AREA		Chem Systems BASE EQUIPMENT COST ($)	INSTALLED EQUIPMENT COST ($)
600	ETHANOL RECOVERY		
AS-602	Rectification Column	0.37	1.10
	Remaining Equipment		
AS-601	Beer Column	288,032	864,096
AS-603*	Stripping Still	97,763	293,289
AS-640*	Vent Scrubber	105,815	317,446
T-601	Degasser Drum	42,464	59,449
T-602	Beer Column Reflux Drum	9,183	25,713
T-603	Fusel Oil Decanter	5,052	14,145
T-605	Rectification Column Reflux Drum	9,183	25,713
T-607*	Extraction Still Reflux Drum	9,183	25,713
T-630	Recycled Water Tank	22,815	52,475
pp-601	Beer Column Bottoms	78,367	109,714
pp-603	Beer Column Reflux	10,663	29,856
pp-604A/S	Wash Return	2,416	6,764
pp-605A/S	Fusel Oil	2,416	6,764
pp-607	Rectification Column Bottoms	2,856	7,998
pp-608	Rectification Column Reflux	19,737	55,263
pp-610*	Stripping Still Reflux	11,469	32,114
pp-611*	Stripping Still Bottoms	5,060	14,169
pp-631	Recycled Water	19,750	55,299
pp-632A/S	Sump	3,033	8,493
pp-641*	Vent Scrubber Return Ethanol	3,361	9,410
GS-611A/B	Sludge Screws	39,850	55,790
TT-603	Beer Column Reboiler	94,731	198,936
TT-605	Beer Column Condenser	83,144	174,603
TT-607	Fusel Oil Cooler	1,173	2,463
TT-609	Rectification Column Reboiler	55,369	116,275
TT-610	Rectification Column Condenser	53,960	113,315
TT-632*	Stripping Still Reboiler	25,069	52,645
TT-631*	Stripping Still Condenser	88,465	185,777
TT-613	Feed Preheater	21,263	44,653
TT-615	Feed Cross Exchanger	27,361	57,457
GC-609A/B/C	Centrifuge	713,340	927,342
FAN-640*	FAN	19,272	26,981
	Total ($ MM)	1.97	3.97
	TOTAL ($ MM)	2.34	5.07
700	OFF-SITE TANKAGE		
T-701A/B	Ethanol Product Tank	622,743	871,840
T-703	Sulfuric Acid Storage Tank	119,564	143,477
T-704	Fire Water Tank	143,506	200,909
T-706A/B	NH3 Storage Tank	85,023	238,065
T-707	Antifoam Storage Tank	22,836	52,522
T-708	Diesel Fuel Tank	31,935	44,709
T-710	Gasoline Storage Tank	60,270	84,379
T-720	Corn Steep Liquor Tank	37,519	52,527
T-730*	Lime Slurry Storage Tank	112,260	134,712
pp-701A/B/S	Ethanol Export	13,535	37,898
pp-703A/S	Sulfuric Acid Transfer	8,492	16,983
pp-704A/S	Fire Water	17,897	50,111
pp-706A/S	NH3 Transfer	6,903	19,328
pp-707A/S	Antifoam Transfer	2,416	6,764
pp-708A/S	Diesel Fuel	3,284	9,195
pp-710A/S	Gasoline Blending	2,416	6,764
pp-720A/S	Corn Steep Liquor Transfer	8,079	16,158
GF-703	Desiccant Air Filter	41,004	57,405
	TOTAL ($ MM)	1.34	2.04

$0.134 mm for stripping still
~7%

OUTPUT BY SECTION

PLANT AREA		*Chem Systems* BASE EQUIPMENT COST ($)	INSTALLED EQUIPMENT COST ($)
800	**WASTE TREATMENT**		
MS-805	Reactor Surge Drum	29,449	67,733
MS-806	Offgas K.O. Suction Pot	13,179	30,311
MS-809	Offgas Knock Out Drum	13,179	30,311
MS-810	LP Vent Knock Out Drum	5,546	12,755
T-803	Equalization Tank	173,540	242,956
T-804	Anaerobic Reactor	850,000	1,190,000
T-807	Biotreater	1,609,631	2,253,484
800 ?*	Pressure Swing Adsorption Oxygen Generator	6,880,000	8,256,000
800 ?*	Sludge Storage Tank	511,429	716,000
pp-808A/S	Primary Heat Exchanger Influent Pump	3,538	9,907
pp-809A/S	Seconday Heat Exchanger Influent Pump	3,538	9,907
pp-813A*	Return Activated Sludge	7,182	14,363
pp-813B*	Waste Activated Sludge	5,174	10,348
pp-816A/S	Final Effluent	14,368	40,229
GS-801	Sludge Screws	29,046	40,664
new*	Bar Screens	147,712	177,254
TT-801	Offgas Cooler	15,667	32,901
TT-802	Feed Cooler(Primary Heat Exchanger)	32,241	67,706
TT-803A	Seconday Heat Exchanger A: Cooling Water	68,257	143,340
TT-803B*	Seconday Heat Exchanger B: Chilled Water	52,357	109,951
GC-801	Sludge Centrifuge	135,270	175,852
GO-806	Offgas Burner	21,136	25,363
GV-808	Secondary Clarifier	150,000	180,000
PB-810	Offgass Blower	78,520	109,928
PB-817A/S	LP Vent Blower	154,293	216,010
OSBL*	Equalization Tank Mixers	65,951	79,142
OSBL*	Nutrient Feed System	45,118	54,141
OSBL*	Anaerobic Mixers	235,554	282,664
OSBL*	Mist System and Backup Carbon	323,921	388,706
OSBL*	Biofilter	12,533	15,039
OSBL*	Storage Tank Mixers	211,465	253,758
	TOTAL ($ MM)	**11.90**	**15.24**

1.4

1.2

OUTPUT BY SECTION

PLANT AREA		Chem Systems BASE EQUIPMENT COST ($)	INSTALLED EQUIPMENT COST ($)
900	**UTILITIES**		
	Boiler Feed Water		
MS-902	Blowdown Flash Drum	5,825	16,309
MS-903	Hydrazine Drum	5,812	8,718
MS-904	Condensate Surge Drum	26,009	72,825
T-930	Condensate Collection Tank	50,231	80,369
pp-906A/S	Blowdown	3,284	9,195
pp-907	Hydrazine Transfer	1,950	3,900
pp-909A/S	Dearator Feed	11,250	31,499
pp-910A/S	Condensate	13,845	38,767
GU-903A/B	Demineralizers	651,412	781,694
GU-904A/S	Condensate Polisher	211,360	253,632
GU-907	Hydrazine Addition Package	15,852	19,022
GU-908	Ammonia Addition Package	15,852	19,022
GU-909	Phosphate Addition Package	15,852	19,022
GV-906	Dearator	140,554	393,552
pp-908A/S	Boiler Feed Water	114,210	159,894
HB-901A	Steam Boiler	19,353,952	29,030,928
	Total ($ MM)	**20.64**	**30.94**
	Process Water		
GF-901	Sand Filter	41,849	58,589
T-901	Process Water Tank	56,179	78,650
T-905	Backwash Transfer Tank	25,699	59,107
pp-902A/S	Process Water Transfer	19,748	55,294
pp-903A/S	Process Water Circulating	28,161	78,850
pp-904A/B	Backwash Feed	23,835	66,737
pp-905A/B	Backwash Transfer	2,930	8,203
pp-913A/S	Well Water	14,910	41,747
	Total ($ MM)	**0.21**	**0.45**
	Turbogenerator		
pp-901A/S	Turbine Condensate	4,841	13,554
GZ-911	Turbo Generator	9,873,873	14,810,809
	Total ($ MM)	**9.88**	**14.82**
	Cooling Water pumps		
pp-912A-F/S	Cooling Water	163,792	458,617
GT-912	Cooling Tower System	2,438,848	2,926,617
	Total ($ MM)	**2.60**	**3.39**
PK-951	**Chilled Water Package**	**2.79**	**3.35**
	Plant and Fermentation Air		
MS-906	Plant Air Receiver	19,945	55,845
MS-907	Instrument Air Receiver	19,945	55,845
GY-910	Instrument Air Dryer	24,412	34,177
PC-911	Air Compressor	55,258	71,835
PK-950A/B/S	Air Compressor Package(fermentation)	4,464,603	5,357,523
	Total ($ MM)	**4.58**	**5.58**
	CIP/CS		
T-961	Cleaning Tank	24,434	56,199
T-960	Sterilization Tank	40,458	60,686
T-963	Sterile Rinse Water Tank	24,434	56,199
pp-960A/S	Supply	4,660	9,321
pp-965A/B/C/S	CIP/CS Sump	4,831	13,528
GA-960	Sterilization Tank Agitator	12,417	14,900
GA-961	Cleanig Tank Agitator	12,417	14,900
T-953	Sterile Water Tank	40,458	60,686
pp-953	Sterile Water	1,950	3,900
TT-953	Water Sterilizer	3,410	7,162
	Total ($ MM)	**0.17**	**0.30**
	TOTAL ($ MM)	**40.87**	**58.81**
TOTAL		**78.33**	**113.63**

TABLE 1
COST OF PRODUCTION ESTIMATE FOR:ETHANOL
PROCESS:BIOMASS PER CSI

Plant start-up	4Q93
Analysis date	4Q93
Location	SE US
Capacity	159.3 Thousand MT/yr 54.0 Millions gallons per year
Operating rate	100 percent
Throughput	159.3 Thousand MT/yr

CAPITAL COST	MILLION U.S. $
ISBL	58.2
OSBL	128.1
Total Plant Capital	186.3
Other Project Costs	18.6
Total Capital Investment	204.9
Working capital	13.2

PRODUCTION COST SUMMARY		UNITS Per MT Product	PRICE U.S. $ /Unit	U.S. $ Per MT	ANNUAL COST MM U.S. $	U.S. $ Per Gal
RAW MATERIALS	Wood (dry), MT	3.4613	46	160.244	25.53	
	Sulfuric Acid, MT	0.0551	72	3.947	0.63	
	Lime, MT	0.0416	50	2.063	0.33	
	Ammonia, MT	0.0374	129	4.829	0.77	
	Corn steep liquor, MT	0.0095	243	2.304	0.37	
	Nutrients, MT	0.0215	273	5.868	0.93	
	Antifoam, MT	0.0006	573	0.344	0.05	
	Glucose, MT	0.0083	1,168	9.698	1.55	
	Gasoline, MT	0.0500	165	8.245	1.31	
	Diesel, MT	0.0135	156	2.108	0.34	
	Catalyst & Chemicals		22	22.046	3.51	
	TOTAL RAW MATERIALS			221.697	35.32	0.65
BY-PRODUCT CREDITS	Solids Disposal, MT	0.15635	(20)	3.127	0.50	
	TOTAL BY-PRODUCT CREDITS			3.127	0.50	0.01
NET RAW MATERIALS				224.824	35.82	0.66
UTILITIES	Purchased Power, MWH	-0.25422	42	(10.677)	(1.70)	
	Raw water, MT	30.99803	0	0.819	0.13	
	TOTAL UTILITIES			(9.858)	(1.57)	(0.03)
VARIABLE COST				214.966	34.25	0.63
DIRECT FIXED COSTS	Labor, 41 Men	32.70 Thousand U.S. $		8.415	1.34	
	Foremen, 9 Men	37.10 Thousand U.S. $		2.096	0.33	
	Super., 1 Men	44.80 Thousand U.S. $		0.281	0.04	
	Maint., Material & Labor	3.00 % of ISBL		10.956	1.75	
	Direct Overhead	45 % Labor & Supervision		4.856	0.77	
	TOTAL DIRECT FIXED COSTS			26.604	4.24	0.08
ALLOCATED FIXED COSTS	General Plant Overhead	65 % Labor & Maintenance		14.136	2.25	
	Insurance, Property Tax	0.7 % Total Plant Capital		8.185	1.30	
	TOTAL ALLOCATED FIXED COSTS			22.321	3.56	0.07
TOTAL CASH COST				263.891	42.05	0.78
Annual Capital Charge		20 % total capital investment		257.257	40.99	
Cost of denatured ethanol				521.148	83.03	1.54

3-31-94, PROCESS : BIOMASS1, PRICE : NREL1Q94, JOB : 7951

APPENDIX V
EQUIPMENT LIST

DATE 08-Dec-94

23.94
6.54
30.48

VESSELS

CSI ITEM #	EQUIPMENT NAME	CSI ACTUAL FRACTION FULL	CSI P psi	CSI H or V	CSI MATERIAL	CSI sensitivity CAPACITY (m^3)	CSI quant.	CSI 1993 $/UNIT	CSI 1993 TOTAL$	CSI INSTALLED FACTOR	CSI INSTALLED TOTAL $	CSI SOURCE
T-201	Sulfuric Acid Storage	0.9	atm	V	SS,316	42	1	45,371	45,371	1.2	54,445	PDQ$
T-203	Blowdown Tank	0.5	15	V	SS,316	*31*	1	36,337	36,337	1.2	43,605	PDQ$
T-206	Neutralization Reaction Tank	0.8	15	V	SS,316	*91*	1	63,956	63,956	1.2	76,747	PDQ$
T-220*	Lime Slurry Tank	1	atm	V	SS,316	*29*	1	35,387	35,387	1.2	42,465	PDQ$
FM-303	Xylose Fermenter	0.95	15	V	CS	2839	*8*	183,142	1,465,137	1.4	2,051,192	PDQ$
FM-305/10	Xylose Seed Fermenter	0.95	15	V	CS	*1170*	1	105,132	105,132	1.4	147,185	PDQ$
FM-305/10	Xylose Seed Fermenter	0.95	15	V	CS	*117*	1	36,361	36,361	1.4	50,906	PDQ$
FM-305/10	Xylose Seed Fermenter	0.95	15	V	CS	*12*	1	13,824	13,824	2.3	31,796	PDQ$
FM-305/10	Xylose Seed Fermenter	0.95	15	V	CS	*1*	1	4,525	4,525	2.3	10,408	PDQ$
FM-305/10	Xylose Seed Fermenter	0.95	15	V	CS	*0.12*	1	1,481	1,481	2.3	3,407	PDQ$
FM-305/10	Xylose Seed Fermenter	0.95	15	V	CS	*0.01*	1	485	485	2.3	1,115	PDQ$
T-301	Seed Hold Tank	0.5	15	V	CS	1,170	1	105,132	105,132	1.4	147,185	PDQ$
T-321	Base Tank	0.9	300	H	CS	*9.18*	1	14,203	14,203	2.8	39,768	PDQ$
FM-400	Cellulase Fermenter	0.8	15	V	CS, lined	805	*2*	126,780	253,560	1.6	405,696	Vendor
FM-401/4	Cellulase Seed Fermenter	0.8	15	V	CS, lined	*43*	2	35,355	70,710	1.4	98,994	Vendor/PDQ$
FM-401/4	Cellulase Seed Fermenter	0.8	15	V	SS, 316	*2*	2	8,949	17,897	1.5	26,846	Vendor/PDQ$
FM-401/4	Cellulase Seed Fermenter	0.8	15	V	SS, 316	*0.11*	2	1,851	3,702	1.5	5,553	Vendor/PDQ$
FM-401/4	Cellulase Seed Fermenter	0.8	15	V	SS, 316	*0.01*	2	383	766	1.5	1,149	Vendor/PDQ$
T-400	Media Prep Tank	1	15	V	CS	*4*	1	8,490	8,490	2.3	19,526	PDQ$
T-403A/B	Antifoam Tank	1	15	V	CS	1	2	3,853	7,707	2.3	17,725	PDQ$
T-405	Sterile Feed Tank	0.9	10	V	CS	*746*	1	79,361	79,361	1.4	111,105	PDQ$
T-410A/B	Cellulase Hold Tank	0.9	atm	V	CS, lined	*746*	1	117,757	117,757	1.6	188,410	Vendor
FM-500	SSF Fermenter	0.95	atm	V	CS, lined	2,839	*30*	305,962	9,178,867	1.6	14,686,187	Vendor
FM-501/6	SSF Seed Fermenter (S.c.)	0.95	10	V	CS, lined	*2173*	1	253,789	253,789	1.6	406,063	Vendor
FM-501/6	SSF Seed Fermenter (S.c.)	0.95	10	V	CS, lined	*217*	1	70,124	70,124	1.6	112,199	Vendor/PDQ$
FM-501/6	SSF Seed Fermenter (S.c.)	0.95	10	V	CS, lined	*22*	1	26,660	26,660	2.3	61,319	Vendor/PDQ$
FM-501/6	SSF Seed Fermenter (S.c.)	0.95	10	V	SS, 316	*2*	1	8,999	8,999	1.5	13,498	Vendor/PDQ$
FM-501/6	SSF Seed Fermenter (S.c.)	0.95	10	V	SS, 316	*0.22*	1	2,680	2,680	1.5	4,020	Vendor/PDQ$
FM-501/6	SSF Seed Fermenter (S.c.)	0.95	10	V	SS, 316	*0.02*	1	798	798	1.5	1,197	Vendor/PDQ$
T-501A	Seed Hold Tank (S.c.)	0.95	10	V	CS,lined	2173	1	253,789	253,789	1.6	406,063	Vendor
T-601	Degasser Drum	0.2	15	V	CS	*198*	1	43,374	43,374	1.4	60,723	PDQ$
T-602	Beer Column Reflux Drum	–	50	H	CS	4	1	9,183	9,183	2.8	25,713	PDQ$
T-603	Fusel Oil Decanter	0.5	25	H	CS	*1.20*	1	5,208	5,208	2.8	14,584	PDQ$
T-605	Rectification Column Reflux Drum	–	25	H	CS	4	1	9,183	9,183	2.8	25,713	PDQ$
T-607*	Extraction Still Reflux Drum	–	25	H	CS	4	1	9,183	9,183	2.8	25,713	PDQ$
T-630	Recycled Water Tank	1	15	V	CS	35	1	23,590	23,590	2.3	54,258	PDQ$
							ISBL		12,382,712	1.57	19,472,481	

DATE 08-Dec-94

VESSELS

CSI ITEM #	EQUIPMENT NAME	*CSI* ACTUAL FRACTION FULL	*CSI* P psi	*CSI* H or V	*CSI* MATERIAL	*CSI* *sensitivity* CAPACITY (m^3)	*CSI* quant.	*CSI* 1993 $/UNIT	*CSI* 1993 TOTAL$	*CSI* INSTALLED FACTOR	*CSI* INSTALLED TOTAL $	*CSI* SOURCE
T-701A/B	Ethanol Product Tank	0.8	atm	V	CS	3891	3	223,081	669,242	1.4	936,938	PDQ$
T-703	Sulfuric Acid Storage Tank	0.8	atm	V	SS, 316	378	1	119,564	119,564	1.2	143,477	PDQ$
T-704	Fire Water Tank	0.8	atm	V	CS	1923	1	143,506	143,506	1.4	200,909	PDQ$
T-706A/B	NH3 Storage Tank	0.8	300	H	CS	32	2	42,580	85,160	2.8	238,449	PDQ$
T-707	Antifoam Storage Tank	0.8	atm	V	CS	35	1	23,611	23,611	2.3	54,305	PDQ$
T-708	Diesel Fuel Tank	0.8	atm	V	CS	79	1	31,935	31,935	1.4	44,709	PDQ$
T-710	Gasoline Storage Tank	0.8	atm	V	CS	540	1	64,771	64,771	1.4	90,679	PDQ$
T-720	Corn Steep Liquor Tank	0.8	atm	V	CS	128	1	37,519	37,519	1.4	52,527	PDQ$
T-730*	Lime Slurry Storage Tank	0.8	atm	V	SS, 316	411	1	112,590	112,590	1.2	135,108	PDQ$
MS-806	Offgas K.O. Suction Pot	1	15	V	CS	11	1	13,179	13,179	2.3	30,311	PDQ$
MS-809	Offgas Knock Out Drum	1	15	V	CS	11	1	13,179	13,179	2.3	30,311	PDQ$
MS-810	LP Vent Knock Out Drum	1	15	V	CS	2	1	5,546	5,546	2.3	12,755	PDQ$
T-803	Equalization Tank		atm	V	CS	3029	1	190,704	190,704	1.4	266,985	PDQ$
T-804	Anaerobic Reactor			V	CS	7571	3	327,804	983,412	1.4	1,376,777	PDQ$
T-807	Biotreater			V	concrete	2555	2	595,196	1,190,392	1.4	1,666,548	HILL
800*	Pressure Swing Adsorption Oxygen Generator					18	1	528,245	528,245	1.2	633,894	HILL
MS-902	Blowdown Flash Drum			H	CS	2	1	5,825	5,825	2.8	16,309	PDQ$
MS-903	Hydrazine Drum		10	V	SS,316	1	1	5,812	5,812	1.5	8,718	PDQ$
MS-904	Condensate Surge Drum			H	CS	43	1	26,009	26,009	2.8	72,825	PDQ$
MS-906	Plant Air Receiver		150	V	CS	9	1	19,945	19,945	2.8	55,845	PDQ$
MS-907	Instrument Air Receiver		150	V	CS	9	1	19,945	19,945	2.8	55,845	PDQ$
T-901	Process Water Tank	1	atm	V	CS	428	1	56,017	56,017	1.4	78,423	PDQ$
T-905	Backwash Transfer Tank		atm	V	CS	42	1	25,699	25,699	2.3	59,107	PDQ$
T-930	Condensate Collection Tank			V	CS/Rubber	6	1	50,231	50,231	1.6	80,369	PDQ$
T-953	Sterile Water Tank		atm	V	SS	38	1	40,458	40,458	1.5	60,686	PDQ$
T-960	Sterilization Tank		atm	V	SS,304	38	1	40,458	40,458	1.5	60,686	PDQ$
T-961	Cleaning Tank		atm	V	CS	38	1	24,434	24,434	2.3	56,199	PDQ$
T-963	Sterile Rinse Water Tank		atm	V	CS	38	1	24,434	24,434	2.3	56,199	PDQ$
							OSBL		4,551,817	1.44	6,575,893	
							TOTAL		16,934,529	1.54	26,048,373	

$18\,m^3 * \frac{1\,ft^3}{.028317\,m^3}$ *

DATE 08-Dec-94

PUMPS

CSI ITEM #	PUMP NAME	CSI GPM	VARIABLE CSI m^3/h	CSI STREAM	CSI DELTA P psi	CSI hydraulic kW	CSI hydraulic HP	CSI MATERIAL	CSI TYPE	CSI quant	CSI 1993 $/UNIT	CSI INSTALLED FACTOR	CSI INSTALLED TOTAL$	CSI source
pp-101	Flume	2067	*469*	product s -	5	4	6	Ductile Iron	Lobe	1	10,496	1.4	14,695	Vendor; lobe
pp-201	Sulfuric Acid	7	*2*	215	75	0.23	0.30	SS	Centrifugal	2	1,950	2.0	7,799	PDQ$; centrifugal
pp-202	Hydrolyzate	1932	*439*	218	30	25	34	Ductile Iron	Lobe	2	34,082	1.4	95,429	Vendor; lobe
pp-203A/S	Neutralized Hydrolyzate	1929	*438*	2205	60	50	67	Ductile Iron	Lobe	2	54,652	1.4	153,027	Vendor; lobe
pp-221*	Slurry Metering Pump	–	FIXED		–	1.03	1	Ductile Iron	Lobe	2	3,845	1.4	10,767	Vendor; lobe
pp-303*	Xylose Fermenter Product Pump	1997	*454*	308	50	43	58	Ductile Iron	Lobe	2	49,416	1.4	138,365	Vendor; lobe
pp-401A/S	Feed	1200	273	FIXED	25	13	17	Ductile Iron	Lobe	2	21,735	1.4	60,856	Vendor; lobe
pp-403A/S	Fermenter Recycle	1200	273	FIXED	50	26	35	Ductile Iron	Lobe	2	34,895	1.4	97,706	Vendor; lobe
pp-411A/S	Prep Tank	1	*0.21*	415	25	0.01	0.01	CS	Centrifugal	2	1,208	2.8	6,764	PDQ$; centrifugal
pp-412	Cellulase Feed	106	*24*	420	50	2.31	3	Ductile Iron	Lobe	2	6,665	1.4	18,661	Vendor; lobe
pp-501*	SSF Seed Transfer Pump	422	*96*	502	50	9	12	SS	Lobe	2	30,303	1.4	84,848	Vendor; lobe
pp-505	Beer Transfer	2089	*475*	510	120	109	146	SS	Lobe	2	176,856	1.4	495,197	Vendor; lobe
pp-601	Beer Column Bottoms	1908	*433*	6209	40	33	44	Ductile Iron	Lobe	2	41,122	1.4	115,141	Vendor; lobe
pp-603	Beer Column Reflux	501	*114*	6212	50	11	15	CS	Centrifugal	2	5,522	2.8	30,922	PDQ$; centrifugal
pp-604A/S	Wash Return	2	*0.44*	510	40	0.03	0.04	CS	Centrifugal	2	1,208	2.8	6,764	PDQ$; centrifugal
pp-605A/S	Fusel Oil	0	*0.06*	510	30	0.00	0.00	CS	Centrifugal	2	1,208	2.8	6,764	PDQ$; centrifugal
pp-607	Rectification Column Bottoms	42	*10*	6213	40	0.73	1	CS	Centrifugal	2	1,386	2.8	7,761	PDQ$; centrifugal
pp-608	Rectification Column Reflux	857	*195*	6215	100	37	50	CS	Centrifugal	2	10,365	2.8	58,042	PDQ$; centrifugal
pp-621	Ethanol Storage	122	*28*	6215	30	2	2	CS	Centrifugal	1	2,066	2.8	5,785	PDQ$; centrifugal
pp-622	Bottoms to WWT	42	*10*	6213	30	1	1	CS	Centrifugal	1	1,208	2.8	3,382	PDQ$; centrifugal
pp-631	Recycled Water	1854	*421*	6304	45	36	49	CS	Centrifugal	2	10,227	2.8	57,272	PDQ$; centrifugal
pp-632A/S	Sump	–	FIXED	fixed	20	0.87	1	CS	Centrifugal	2	1,517	2.8	8,493	PDQ$; centrifugal
pp-641*	Vent Scrubber Return Ethanol	85	*19*	6409	30	1	1	CS	Centrifugal	2	1,715	2.8	9,604	PDQ$; centrifugal
			–							ISBL		1.50	1,494,044	

DATE 08-Dec-94

PUMPS

CSI ITEM #	PUMP NAME	CSI GPM	VARIABLE CSI m^3/h	CSI STREAM	CSI DELTA P psi	CSI hydraulic kW	CSI hydraulic HP	CSI MATERIAL	CSI TYPE	CSI quant	CSI 1993 $/UNIT	CSI INSTALLED FACTOR	CSI INSTALLED TOTAL$	CSI source
pp-701A/B/S	Ethanol Export	525	119	none	30	7	9	CS	Centrifugal	3	4,512	2.8	37,898	PDQ$; centrifugal
pp-703A/S	Sulfuric Acid Transfer	100	23	none	40	2	2	SS	Centrifugal	2	4,246	2.0	16,983	PDQ$; centrifugal
pp-704A/S	Fire Water	600	136	none	100	26	35	CS	Centrifugal	2	8,948	2.8	50,111	PDQ$; centrifugal
pp-706A/S	NH3 Transfer	200	45	none	40	3	5	CS	Centrifugal	2	3,451	2.8	19,328	PDQ$; centrifugal
pp-707A/S	Antifoam Transfer	10	2	none	40	0.17	0.23	CS	Centrifugal	2	1,208	2.8	6,764	PDQ$; centrifugal
pp-708A/S	Diesel Fuel	25	6	none	50	0.54	0.73	CS	Centrifugal	2	1,642	2.8	9,195	PDQ$; centrifugal
pp-710A/S	Gasoline Blending	8	2	none	30	0.10	0.13	CS	Centrifugal	2	1,208	2.8	6,764	PDQ$; centrifugal
pp-720A/S	Corn Steep Liquor Transfer	60	14	none	60	2	2	SS	Centrifugal	2	4,039	2.0	16,158	PDQ$; centrifugal
pp-808A/S	Primary Heat Exchanger Influent Pump	1013	230	none	20	9	12	CS	Centrifugal	2	4,954	2.8	9,907	PDQ$; centrifugal
pp-809A/S	Seconday Heat Exchanger Influent Pump	1013	230	none	20	9	12	CS	Centrifugal	2	4,954	2.8	9,907	PDQ$; centrifugal
pp-813A*	Return Activated Sludge	1013	230	none	20	9	12	SS	Centrifugal	2	7,182	2.0	14,363	PDQ$; centrifugal
pp-813B*	Waste Activated Sludge	506	115	none	20	4	6	SS	Centrifugal	2	5,174	2.0	10,348	PDQ$; centrifugal
pp-816A/S	Final Effluent	1047	207	none	40	18	24	CS	Centrifugal	2	7,184	2.8	40,229	PDQ$; centrifugal
pp-901A/S	Turbine Condensate	419	190	none	40	7	10	CS	Centrifugal	2	5,040	2.8	28,224	PDQ$; centrifugal
pp-902A/S	Process Water Transfer	2597	602	none	30	34	45	CS	Centrifugal	2	9,874	2.8	55,294	PDQ$; centrifugal
pp-903A/S	Process Water Circulating	2597	602	none	60	68	91	CS	Centrifugal	2	14,080	2.8	78,850	PDQ$; centrifugal
pp-904A/B	Backwash Feed	6000	1363	none	20	52	70	CS	Centrifugal	2	11,917	2.8	66,737	PDQ$; centrifugal
pp-905A/B	Backwash Transfer	50	11	none	20	0.43	0.58	CS	Centrifugal	2	1,465	2.8	8,203	PDQ$; centrifugal
pp-906A/S	Blowdown	50	11	none	25	0.54	0.73	CS	Centrifugal	2	1,642	2.8	9,195	PDQ$; centrifugal
pp-907	Hydrazine Transfer	5	1	none	20	0.04	0.06	SS	Centrifugal	1	1,950	2.0	3,900	PDQ$; centrifugal
pp-908A/S	Boiler Feed Water	1229	237	none	1250	668	896	SS	Centrifugal,staged	2	55,653	1.4	155,829	PDQ$; centrifugal
pp-909A/S	Dearator Feed	1229	237	none	20	11	14	CS	Centrifugal	2	5,470	2.8	30,634	PDQ$; centrifugal
pp-910A/S	Condensate	1229	237	none	30	16	21	CS	Centrifugal	2	6,732	2.8	37,701	PDQ$; centrifugal
pp-913A/S	Well Water	1800	409	none	25	20	26	CS	Centrifugal	2	7,455	2.8	41,747	PDQ$; centrifugal
pp-953	Sterile Water	10	2	none	30	0.13	0.17	SS	Centrifugal	1	1,950	2.0	3,900	PDQ$; centrifugal
pp-960A/S	Supply	20	5	none	50	0.43	0.58	SS	Centrifugal	2	2,330	2.0	9,321	PDQ$; centrifugal
pp-965A/B/C/S	CIP/CS Sump	20	5	none	30	0.26	0.35	CS	Centrifugal	4	1,208	2.8	13,526	PDQ$; centrifugal
										OSBL		2.27	791,018	
										TOTAL		1.70	2,285,062	

DATE 08-Dec-94

SOLIDS HANDLING EQUIPMENT

CSI ITEM #	*CSI* EQUIPMENT NAME	*CSI* TYPE	*SERI* DUTY DESCRIPTION	*CSI* kW/UNIT	*CSI* MATERIAL	*CSI* QUANT	*CSI* 1993 $/UNIT	*CSI* INSTALLED FACTOR	*CSI* INSTALLED TOTAL $	*CSI* SOURCE
GS-103	Magnetic Chip Cleaner		remove down to 0.5" nuts	5	CS	1	10,882	1.2	13,058	SERI escalated 91-93
~~GM-101A/B/S~~	~~Front End Loaders~~	~~Diesel~~		–		3	164,861	1.2	494,582	SERI escalated 91-93
GS-101	Radial Stacking Conveyor	Paddle	1500 ton/h wght, 120ft x 30	11	CS	1	131,984	1.4	184,777	SERI escalated 91-93
GS-102	Belt Conveyer	Belt	240ft x 6.5ft wide, 200 t/h	7	CS	1	202,589	1.4	283,624	SERI escalated 91-93
GS-104	Milled Chip Belt Conveyor	Belt	50ft x 6.5ft wide, 200 t/h	4	CS	1	42,272	1.4	59,181	SERI escalated 91-93
GY-101A/B/C/D	Wood Chip Unloader with Scale	23-TON/LOAD	10 van/hr/loader	26	CS	4	41,648	1.2	199,913	SERI escalated 91-93
GG-101A/B/C/D	Disk Refiner		128 hp-h/dry ton	1864	CS	4	375,000	1.3	1,950,000	Andritz Sprout-Bauer,
GS-223	Lime Unloading Conveyor	Bucket	120 ft high, 100t/h	37	CS	1	19,022	1.4	26,631	SERI escalated 91-93
GS-226*	Rail Car weigh station			–		1	60,000	1.2	72,000	Fairbanks Scales
GS-611A/B	Sludge Screws	Screw, 18 in	150 FEET	7	CS	2	19,925	1.4	55,790	CPEIEC
							ISBL	1.29	3,339,557	
GS-801	Sludge Screws	Screw, 9 in	100 FEET	1	CS	2	14,523	1.4	40,664	CPEIEC
new*	Bar Screens	Mechanically Cleaned	1/2 inch	–		1	59,085	1.2	70,902	Hill
							OSBL	1.27	111,566	
							TOTAL	1.29	3,451,123	

1991 → 1993
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DATE 08-Dec-94

MISCELLANEOUS

CSI ITEM #	*SERI* EQUIPMENT NAME	DUTY DESCRIPTION	*CSI* HP /1000 gal	*CSI* variable total gal	*CSI* MATERIAL	*CSI* QUANT	*CSI* BASE $/UNIT	*CSI* INSTALLED FACTOR	*CSI-sensitivity* INSTALLED TOTAL $	*CSI* SOURCE
GA-201	Line Mixer			*15*	SS, 316	1	222	1.2	267	PDQ$ Agitator: In-line mixer
GA-203	Blowdown Tank Agitator	Single Impeller	2	*8153*	SS, 316	3	6,543	1.2	23,555	PDQ$ Agitator: Turbine mixer
GA-213	Neutralization Tank Agitator	Single Impeller	2	*24152*	SS, 316	3	9,832	1.2	35,396	PDQ$ Agitator: Turbine mixer
GF-201	Desiccant Air Filter	0.5 cfm		none	Silica	1	1,057	1.4	1,480	SERI, escalated 91-93
MR-201/MR-202	Pre-Hydrolysis System (w/ plug screw feeder)	1920 tons/day		none	SS, 316	1	4,560,000	1.5	6,840,000	Sunds DeVibrators
GA-301	Seed Hold Tank Agitator	Single Impeller/40 HP	0.2	*309025*	SS, 316	3	10,784	1.2	38,824	PDQ$ Agitator: Turbine mixer
GA-303A-H	Xylose Fermenter Agitator	Single Impeller	0.1	*6000000*	SS, 316	*24*	11,596	1.2	333,964	PDQ$ Agitator: Turbine mixer
GA-305	First Seed Vessel Agitator	Single Impeller	0.2	*309025*	SS, 316	3	10,784	1.2	38,824	PDQ$ Agitator: Turbine mixer
GA-306	Second Seed Vessel Agitator	Single Impeller	1.5	*30902*	SS, 316	3	9,681	1.2	34,853	PDQ$ Agitator: Turbine mixer
GA-307	Third Seed Vessel Agitator	Single Impeller	1.5	*3090*	SS, 316	1	9,306	1.2	11,168	PDQ$ Agitator: Turbine mixer
GA-308	Fourth Seed Vessel Agitator	Single Impeller	1.5	*309*	SS, 316	1	3,924	1.2	4,709	PDQ$ Agitator: Turbine mixer
GA-400	Prep Tank Agitator	Single Impeller/10 HP	1	*1131*	SS, 316	1	5,483	1.2	6,580	PDQ$ Agitator: Turbine mixer
GA-401A/B/C	Fermenter Agitator	Single Impeller	1.18	*637975*	SS, 316	*6*	21,234	1.2	152,884	PDQ$ Agitator: Turbine mixer
GA-405	Feed Tank Agitator	Single Impeller/300 HP	2	*197196*	SS, 316	3	21,609	1.2	77,792	PDQ$ Agitator: Turbine mixer
GA-410	Hold Tank Agitator	Single Impeller/200 HP	1	*197196*	SS, 316	3	16,663	1.2	59,986	PDQ$ Agitator: Turbine mixer
GA-411	First Seed Vessel Agitator	Single Impeller	3.5	*22480*	SS, 316	6	9,104	1.2	65,548	PDQ$ Agitator: Turbine mixer
GA-412	Second Seed Vessel Agitator	Single Impeller	3.5	*1136*	SS, 316	2	6,775	1.2	16,259	PDQ$ Agitator: Turbine mixer
GA-413	Third Seed Vessel Agitator	Single Impeller	3.5	*57*	SS, 316	2	2,203	1.2	5,287	PDQ$ Agitator: Turbine mixer
GA-500A-AA	SSF Fermenter Agitator	Single Impeller	0.1	22500000	SS, 316	*90*	11,596	1.2	1,252,365	PDQ$ Agitator: Turbine mixer
GA-501A	Seed Hold Tank Agitator (S.c.)	Single Impeller/50 HP	0.1	*573989*	SS, 316	3	10,489	1.2	37,762	PDQ$ Agitator: Turbine mixer
GA-510A	First Seed Vessel Agitator (S.c.)	Single Impeller	0.1	*573989*	SS, 316	3	10,489	1.2	37,762	PDQ$ Agitator: Turbine mixer
GA-511A	Second Seed Vessel Agitator (S.c.)	Single Impeller	0.5	*57399*	SS, 316	3	8,088	1.2	29,118	PDQ$ Agitator: Turbine mixer
GA-512A	Third Seed Vessel Agitator (S.c.)	Single Impeller	0.5	*5740*	SS, 316	1	7,775	1.2	9,330	PDQ$ Agitator: Turbine mixer
GA-513A	Fourth Seed Vessel Agitator (S.c.)	Single Impeller	0.5	*574*	SS, 316	1	3,279	1.2	3,934	PDQ$ Agitator: Turbine mixer
GC-609A/B/C	Centrifuge	Solid Bowl		*none*		3	237,780	1.3	927,342	SERI, escalated 91-93
FAN-640*	FAN	centrifugal		*none*	Steel	1	19,272	1.4	26,981	PDQ$ Fan; Centrifugal
						ISBL		**1.40**	**10,071,967**	

DATE 08-Dec-94

MISCELLANEOUS

CSI ITEM #	*SERI* EQUIPMENT NAME	DUTY DESCRIPTION	*CSI* HP /1000 gal	*CSI* variable total gal	*CSI* MATERIAL	*CSI* QUANT	*CSI* BASE $/UNIT	*CSI* INSTALLED FACTOR	*CSI-sensitivity* INSTALLED TOTAL $	*CSI* SOURCE
GF-703	Desiccant Air Filter	1500 cfm		*none*	Silica	1	41,004	1.4	57,405	SERI, escalated 91-93
GC-801	Sludge Centrifuge	Solid Bowl		*none*	CS	1	135,270	1.3	175,852	SERI, escalated 91-93
GO-806	Offgas Burner			*none*	CS	1	21,136	1.2	25,363	SERI, escalated 91-93
GV-808	Secondary Clarifier	Center feed, 100 ft diameter		HILL; quanti	CS	*2*	50,000	1.2	120,000	HILL
PB-810	Offgass Blower	2630 cfm, 20 psig discharge		*none*	CS	1	78,520	1.4	109,928	SERI, escalated 91-93
PB-817A/S	LP Vent Blower	2400 cfm, 20 psig discharge		*none*	CS	2	77,146	1.4	216,010	SERI, escalated 91-93
OSBL*	Equalization Tank Mixers		0.2	*800074*	SS	3	23,262	1.2	83,742	PDQ$ Agitator: Turbine mixer
OSBL*	Nutrient Feed System			HILL		1	24,722	1.2	29,666	HILL;escalated
OSBL*	Anaerobic Mixers			quantity	SS	*12*	29,444	1.2	423,997	PDQ$ Agitator: Turbine mixer
OSBL*	Aeration Tank Mixers			HILL		*8*	14,456	1.2	138,773	
OSBL*	Mist System and Backup Carbon			HILL		1	177,490	1.2	212,988	HILL;escalated
OSBL*	Biofilter			HILL		1	6,867	1.2	8,241	HILL;escalated
						OSBL		1.25	1,601,965	

DATE 08-Dec-94

MISCELLANEOUS

CSI ITEM #	*SERI* EQUIPMENT NAME	DUTY DESCRIPTION	*CSI* HP /1000 gal	*CSI* variable total gal	*CSI* MATERIAL	*CSI* QUANT	*CSI* BASE $/UNIT	*CSI* INSTALLED FACTOR	*CSI-sensitivity* INSTALLED TOTAL $	*CSI* SOURCE
GT-912	Cooling Tower System	field erected, Douglas Fir, gpm ->		*64,941*	**64,941**	1	2,563,103	1.2	3,075,724	PDQ$ Cooling Tower
GA-960	Sterilization Tank Agitator	Single Impeller	1	*10,000*	SS, 316	1	12,417	1.2	14,900	PDQ$ Agitator: Turbine mixer
GA-961	Cleanig Tank Agitator	Single Impeller	1	*10,000*	SS, 316	1	12,417	1.2	14,900	PDQ$ Agitator: Turbine mixer
GF-901	Sand Filter	34ft dia. x 8ft high		*none*	CS	1	41,849	1.4	58,589	SERI, escalated 91-93
GU-903A/B	Demineralizers	200 gpm		*none*	CS	2	325,706	1.2	781,694	SERI, escalated 91-93
GU-904A/S	Condensate Polisher	1400 gpm		*none*	SS	2	105,680	1.2	253,632	SERI, escalated 91-93
GU-907	Hydrazine Addition Package	150 gal tank, 2 pumps, 1 agitator		*none*	SS	1	15,852	1.2	19,022	SERI, escalated 91-93
GU-908	Ammonia Addition Package	150 gal tank, 2 pumps, 1 agitator		*none*	SS	1	15,852	1.2	19,022	SERI, escalated 91-93
GU-909	Phosphate Addition Package	150 gal tank, 2 pumps, 1 agitator		*none*	SS	1	15,852	1.2	19,022	SERI, escalated 91-93
GV-906	Dearator	1700 gpm, 17000 gal		*none*	CS/SS	1	140,554	2.8	393,552	SERI, escalated 91-93
GY-910	Instrument Air Dryer	600 scfm/ desiccant		*none*	CS	1	24,412	1.4	34,177	SERI, escalated 91-93
GZ-911	Turbo Generator	MW ->		38.1	**38**	1	9,174,169	1.5	9,174,169	In-house report; 0.7 scaling factc
HB-901A	Steam Boiler	field erected, Lb/hr ->		*497,402*	**497,402**	1	18,999,998	1.3	24,699,997	NREL; 0.5 scaling factor
PC-911	Air Compressor	1000 scfm @ 115 psia		**1000**	CS	1	55,258	1.3	71,835	PDQS, 140 ACFM
PK-950A/B/S	Air Compressor Package(fermentation)	CS, @ 60 psia, SCFM ->		24,440	**24,440**	3	1,419,077	1.2	5,108,677	PDQS, 7000 ACFM
PK-951	Chilled Water Package	CS, 50F, gpm ->		*7496*	**7,496**	1	1,022,607	1.2	1,227,129	SERI, escalated 91-93
						UTILITY TOTAL		1.32	44,966,042	
						OSBL TOTAL		1.31	46,568,007	
						TOTAL		1.33	56,639,974	

DATE 08-Dec-94

TOWERS

CSI ITEM #	EQUIPMENT NAME	*CSI* diameter m	*CSI* height m	*CSI* trays**	*CSI* VOLUME cubic m	*CSI* Design Pressure k Pa	*CSI* Design Pressure psia	*CSI* Design Temp °C	Material Shell/Inernals	*CSI* QUANT	*CSI* BASE $/UNIT	*CSI* INSTALLED FACTOR	*CSI-sensitivity* INSTALLED TOTAL $	*CSI* SOURCE
AS-601	Beer Column	4	35	40	436	621	90	204	CS/CS	1	317,791	3	953,372	PDQ$
AS-602	Rectification Column	4	48	70	506	310	45	204	lined CS/SS	1	593,413	3	1,780,239	PDQ$
AS-640*	Vent Scrubber	4	10	26	123	172	25	93	CS/PP	1	159,887	3	479,661	PDQ$
									1 inch PALL Rings		**1,071,091**	**3**	**3,213,272**	

* Equipment added to design

** Scrubber Column number represents feet of packing

DATE 08-Dec-94

HEAT EXCHANGER

CSI ITEM #	EQUIPMENT NAME	stream	C Q - KW	stream	CSI Q - out t KW	CSI Heat duty MM W	CSI - proce stream	C	stream	C	CSI utility side T2 - in (C)	T2 - out ((	CSI LMTD	CSI m²	CSI TUBE MAT.	CSI SHELL MAT.	CSI DESIGN PRESS. k Pa	CSI DESIGN TEMP. °C	CSI TYPE	CSI quant	CSI 1993 $/UNIT	CSI INSTALLED FACTOR	CSI INSTALLED TOTAL $	CSI SOURCE
TT-220	Feed Cooler	s-2205	-1830000	s-2206	-1.86E+06	31	s-2205	102	s-2206	37	30	44	24	1006	CS	CS	689	38	Fixed Tube	1	127,403	2.1	267,547	PDQ$ Fixed Sheet
TT-301A*	Water Cooler	s-3101	-105600	s-3102	-1.07E+05	1.8	s-3101	100	s-3102	37	30	44	24	120	CS	CS	689	38	Fixed Tube	1	29,567	2.1	62,091	PDQ$ Fixed Sheet
TT-401A*	Water Cooler	s-4101	-194.3	s-4102	-1.96E+02	0.0034	s-4101	100	s-4102	35	30	44	21	0	CS	CS	689	38	Fixed Tube	1	310	2.1	651	PDQ$ Fixed Sheet
TT-401B*	Water Cooler	s-4102	-197.7	s-4103	-1.98E+02	0.0004	s-4102	35	s-4103	28	10	13	20	0.02	CS	CS	689	38	Fixed Tube	1	78	2.1	163	PDQ$ Fixed Sheet
TT-402A	Water Cooler	s-4118	-63360	s-4119	-64480	1.12	s-4118	100	s-4119	35	30	44	21	42	CS	CS	689	38	Fixed Tube	1	14,634	2.1	30,731	PDQ$ Fixed Sheet
TT-402B*	Water Cooler	s-4119	-64480	s-414	-64620	0.14	s-4119	35	s-414	27	10	13	19	6	CS	CS	689	38	Fixed Tube	1	3,884	2.1	8,157	PDQ$ Fixed Sheet
TT-607	Fusel Oil Cooler	x		x		0.02	80	80	38	38	30	44	19	0.98	CS	CS	689	38	Fixed Tube	1	1,222	2.1	2,567	PDQ$ Fixed Sheet
TT-613	Mash Trim Heater	x		x		42.4	s-6203	120	s-6204	120	148	148	28	1185	CS	CS	1034	66	Fixed Tube	1	142,943	2.1	300,181	PDQ$ Fixed Sheet
TT-615	Flash/Mash Exchanger	s-6201	-1.86E+06	s-6202	-1851000	10	s-6201	76	s-6202	97	102	99	12	373	CS	CS	1034	66	Fixed Tube	1	63,520	2.1	133,392	PDQ$ Fixed Sheet
											(s-216)	(s-6207)												
TT-616	Scrub/Flash Exchanger	s-6410	-8.26E+04	s-6205	-81570	1.27	s-6410	37	s-6205	94	99	59	11	87	CS	CS	1034	66	Fixed Tube	1	23,864	2.1	50,113	PDQ$ Fixed Sheet
											(s-6207)	(s-6208)												
TT-621	Beer Column Reboiler	x		x		47.8	s-6206	120	s-6209	149	148	148	28	472	CS	CS	1034	66	Reboiler	2	87,339	2.1	366,822	PDQ$ Reboiler
TT-622	Beer Column Condenser/ Rectification Column Reboiler	s-6219	-229100	s-6220	-206100	23	s-6219	113	s-6220	114	124	118	7	1403	CS	CS	689	38	Fixed Tube	1	160,976	2.1	338,049	PDQ$ Fixed Sheet
											(s-6222)	(s-6223)												
TT-623	Rectification Column O/H Condenser	s-6106	-1861000	s-6201	-1861000	20	s-6106	37	s-6201	76	81	80	18	496	CS	CS	689	38	Fixed Tube	1	77,836	2.1	163,456	PDQ$ Fixed Sheet
											(s-6216)	(s-6217)												
TT-624	Beer Column O/H Trim. Condenser	x		x		32.7	s-6223	118	s-6224	118	30	44	81	178	CS	CS	689	38	Fixed Tube	1	37,797	2.1	79,375	PDQ$ Fixed Sheet
TT-625	Beer Column Bottoms/Scrub Exchanger	s-6205	-81570	s-6206	-81000	0.57	s-6205	94	s-6206	120	149	148	40	6	CS	CS	689	38	Fixed Tube	1	4,150	2.1	8,714	PDQ$ Fixed Sheet
											(s-6209)	(s-6210)												
TT-626	Rectification Column O/H Trim. Condenser	x		x		28.9	s-6217	80	s-6218	79	30	44	42	302	CS	CS	689	38	Fixed Tube	1	54,710	2.1	114,891	PDQ$ Fixed Sheet
TT-627	Rectification Column Bottoms Trim Reboiler	x		x		28	s-6220	114	s-6221	113	148	148	34	204	CS	CS	689	38	Fixed Tube	1	41,592	2.1	87,343	PDQ$ Fixed Sheet
TT-628	Beer Still Bottoms Trim Cooler	S-6225	-1839000	S-6211	-1845000	-6	S-6225	125	S-6211	114	30	44	82	57	CS	CS	689	178	Fixed Tube	1	18,142	2.1	38,098	PDQ$ Fixed Sheet
TT-629	Mash Beer Bottoms Exchanger	S-6202	-1851000	S-6203	-1839000	12	S-6202	97	S-6203	120	148	125	65	145	CS	CS	689	175	Fixed Tube	1	32,685	2.1	68,639	PDQ$ Fixed Sheet
											(s-6210)	(s-6225)												
COILS	Xylose Fermentation Coils	3123	-1911000	3120	-1921000	10	3123	57	3120	37	10	13	35	506	CS	-	689	38	Coils	4802 ft	3	2.5	39,412	vendor
COILS	Xylose Seed Fermentation Coils	3122	-181800	3106	-183000	1.20	3122	50	3106	37	10	13	32	67	CS	-	689	38	ID = 4.5 in.	632	3	2.5	5,056	vendor
COILS	Cellulase Fermentation Coils	4125	-105600	4126	-108800	3.2	4125	59	4126	28	10	13	30	189	CS	-	689	38	Coils	1095 ft	11	2.5	12,048	vendor
COILS	Cellulase Seed Fermentation Coils	4135	-334	4110	-365.2	0.0212	4135	67	4110	28	10	13	33	1	CS	-	689	38	ID = 7.3 in.	7	11	2.5	73	vendor
COILS	SSF Fermentation Coils	5136	-2000000	5125	-2005000	6.00	5136	48	5125	37	10	13	31	343	CS	-	689	38	Coils	3976 ft	7	2.5	27,833	vendor
COILS	SSF Seed Fermentation Coils	5112	-400900	5113	-402400	1.5	5112	48	5113	37	10	13	31	86	CS	-	689	38	ID = 3.5 in.	994	7	2.5	6,958	vendor
																					ISBL	2.11	2,211,360	
TT-801	Offgas Cooler													46	CS	CS	689	38	Fixed Tube	1	15,667	2.1	32,901	PDQ$ Fixed Sheet
TT-802	Feed Cooler(Primary Heat Exchanger)													304	CS	CS	689	38	Fixed Tube	1	54,981	2.1	115,460	PDQ$ Fixed Sheet
TT-803A	Seconday Heat Exchanger A: Cooling Water													567	CS	CS	689	38	Fixed Tube	1	85,173	2.1	178,863	PDQ$ Fixed Sheet
TT-953	Water Sterilizer													5	CS	CS	1034	66	Fixed Tube	1	3,410	2.1	7,162	PDQ$ Fixed Sheet
																					OSBL	2.10	334,387	
																					TOTAL	2.11	2,545,746	

DATE 08–Dec–94

CAPITAL COST ESTIMATE

	ISBL			OSBL			TOTAL			COMMENTS
	BASE	INSTALLED	f*	BASE	INSTALLED	f*	BASE	INSTALLED	f*	
TANKS & VESSELS	12,382,712	19,472,481	1.57	4,551,817	6,575,893	1.44	16,934,529	26,048,373	1.54	
PUMPS	993,520	1,494,044	1.50	348,870	791,018	2.27	1,342,390	2,285,062	1.70	
SOLIDS HANDLING	2,585,345	3,339,557	1.29	88,131	111,566	1.27	2,673,475	3,451,123	1.29	
HEAT EXCHANGERS	1,046,142	2,211,360	2.11	159,232	334,387	2.10	1,205,374	2,545,746	2.11	
MISCELLANEOUS	7,190,473	10,071,967	1.40	1,278,062	1,601,965	1.25	8,468,535	11,673,932	1.38	
COLUMNS	1,071,091	3,213,272	3.00				1,071,091	3,213,272	3.00	
UTILITIES				34,156,286	44,966,042		34,156,286	44,966,042	1.32	
	25,269,282	**39,802,681**	1.58	**40,582,398**	**54,380,870**	1.34				
Building					1,592,107					4% of ISBL installed
Site Development					3,582,241					9.0% of ISBL installed
Additional Piping					1,791,121					4.5% of ISBL installed
Total	**25,269,282**	**39,802,681**		**40,582,398**	**61,346,339**		**65,851,681**	**101,149,020**	1.54	
TOTAL ERECTED COST		39,802,681			61,346,339			**101,149,020**		
Proratable Costs		3,980,268			6,134,634			10,114,902		10% of TEC
Field Expenses		3,980,268			6,134,634			10,114,902		10% of TEC
Home Office Construction and Fee		9,950,670			15,336,585			25,287,255		25% of TEC
Contingency		1,194,080			1,840,390			3,034,471		3% of TEC
		ISBL			OSBL					
TOTAL INVESTMENT		58,907,967			90,792,582			**149,700,549**		
Owner's Cost								14,970,055		10% of Total Investment
TOTAL								**164,670,604**		

* f is the average installation factor.

DATE 08-Dec-94

OUTPUT BY SECTION

PLANT AREA		*Chem Systems* BASE EQUIPMENT COST ($)	INSTALLED EQUIPMENT COST ($)
	100 WOOD HANDLING		
pp-101	Flume	10,496	14,695
GS-103	Magnetic Chip Cleaner	10,882	13,058
GM-101A/B/S	Front End Loaders	412,152	494,582
GS-101	Radial Stacking Conveyor	131,984	184,777
GS-102	Belt Conveyer	202,589	283,624
GS-104	Milled Chip Belt Conveyor	42,272	59,181
GY-101A/B/C/D	Wood Chip Unloader with Scale	166,594	199,913
GG-101A/B/C/D	Disk Refiner	1,500,000	1,950,000
	TOTAL($ MM)	**2.48**	**3.20**
	200 PREHYDROLYSIS		
GS-223	Lime Unloading Conveyor	19,022	26,631
T-201	Sulfuric Acid Storage	45,371	54,445
T-203	Blowdown Tank	36,337	43,605
T-206	Neutralization Reaction Tank	63,956	76,747
T-220*	Lime Slurry Tank	35,387	42,465
pp-201	Sulfuric Acid	3,900	7,799
pp-202	Hydrolyzate	68,163	95,429
pp-203A/S	Neutralized Hydrolyzate	109,305	153,027
pp-221*	Slurry Metering Pump	7,691	10,767
TT-220	Feed Cooler	127,403	267,547
GA-201	Line Mixer	222	267
GA-203	Blowdown Tank Agitator	19,629	23,555
GA-213	Neutralization Tank Agitator	29,497	35,396
GF-201	Desiccant Air Filter	1,057	1,480
MR-201/MR-202	Pre-Hydrolysis System (w/ plug screw feeder)	4,560,000	6,840,000
GS-226*	Rail Car weigh station	60,000	72,000
	TOTAL ($ MM)	**5.19**	**7.75**
	300 XYLOSE FERMENTATION		
	Seed Fermenters		
FM-305/10	Xylose Seed Fermenter	105,132	147,185
FM-305/10	Xylose Seed Fermenter	36,361	50,906
FM-305/10	Xylose Seed Fermenter	13,824	31,796
FM-305/10	Xylose Seed Fermenter	4,525	10,408
FM-305/10	Xylose Seed Fermenter	1,481	3,407
FM-305/10	Xylose Seed Fermenter	485	1,115
	Total ($ MM)	**0.16**	**0.24**
FM-303	**Xylose Fermenters**	**1.47**	**2.05**
	Remaining Equipment		
T-301	Seed Hold Tank	105,132	147,185
T-321	Base Tank	14,203	39,768
pp-303*	Xylose Fermenter Product Pump	98,832	138,365
TT-301A*	Water Cooler	29,567	62,091
COILS	Xylose Fermentation Coils	15,365	38,412
COILS	Xylose Seed Fermentation Coils	2,022	5,056
GA-301	Seed Hold Tank Agitator	32,353	38,824
GA-303A-H	Xylose Fermenter Agitator	278,303	333,964
GA-305	First Seed Vessel Agitator	32,353	38,824
GA-306	Second Seed Vessel Agitator	29,044	34,853
GA-307	Third Seed Vessel Agitator	9,306	11,168
GA-308	Fourth Seed Vessel Agitator	3,924	4,709
	Total ($ MM)	**0.65**	**0.89**
	TOTAL ($ MM)	2.28	3.19

DATE 08–Dec–94

	400 CELLULASE PRODUCTION		
	Seed Fermenters		
FM–401/4	Cellulase Seed Fermenter	70,710	98,994
FM–401/4	Cellulase Seed Fermenter	17,897	26,846
FM–401/4	Cellulase Seed Fermenter	3,702	5,553
FM–401/4	Cellulase Seed Fermenter	766	1,149
	Total ($ MM)	**0.09**	**0.13**
FM–400	**Cellulase Fermenter ($ MM)**	**0.25**	**0.41**
	Remaining Equipment		
T–400	Media Prep Tank	8,490	19,526
T–403A/B	Antifoam Tank	7,707	17,725
T–405	Sterile Feed Tank	79,361	111,105
T–410A/B	Cellulase Hold Tank	117,757	188,410
pp–401A/S	Feed	43,470	60,858
pp–403A/S	Fermenter Recycle	69,790	97,706
pp–411A/S	Prep Tank	2,416	6,764
pp–412	Cellulase Feed	13,329	18,661
TT–401A*	Water Cooler	310	651
TT–401B*	Water Cooler	78	163
TT–402A	Water Cooler	14,634	30,731
TT–402B*	Water Cooler	3,884	8,157
COILS	Cellulase Fermentation Coils	4,819	12,048
COILS	Cellulase Seed Fermentation Coils	29	73
GA–400	Prep Tank Agitator	5,483	6,580
GA–401A/B/Cp451XFermenter Agitator		127,403	152,884
GA–405	Feed Tank Agitator	64,827	77,792
GA–410	Hold Tank Agitator	49,988	59,986
GA–411	First Seed Vessel Agitator	54,623	65,548
GA–412	Second Seed Vessel Agitator	13,549	16,259
GA–413	Third Seed Vessel Agitator	4,406	5,287
	Total ($ MM)	**0.69**	**0.96**
	TOTAL ($ MM)	**1.03**	**1.50**
	500 SSF		
	Seed Fermenters		
FM–501/6	SSF Seed Fermenter (S.c.)	253,789	406,063
FM–501/6	SSF Seed Fermenter (S.c.)	70,124	112,199
FM–501/6	SSF Seed Fermenter (S.c.)	26,660	61,319
FM–501/6	SSF Seed Fermenter (S.c.)	8,999	13,498
FM–501/6	SSF Seed Fermenter (S.c.)	2,680	4,020
FM–501/6	SSF Seed Fermenter (S.c.)	798	1,197
	Total ($ MM)	**0.36**	**0.60**
FM–500	**SSF Fermenter ($ MM)**	**9.18**	**14.69**
	Remaining Equipment		
T–501A	Seed Hold Tank (S.c.)	253,789	406,063
pp–501*	SSF Seed Transfer Pump	60,605	84,848
pp–505	Beer Transfer	353,712	495,197
COILS	SSF Fermentation Coils	11,133	27,833
COILS	SSF Seed Fermentation Coils	2,783	6,958
GA–500A–AA	SSF Fermenter Agitator	1,043,637	1,252,365
GA–501A	Seed Hold Tank Agitator (S.c.)	31,468	37,762
GA–510A	First Seed Vessel Agitator (S.c.)	31,468	37,762
GA–511A	Second Seed Vessel Agitator (S.c.)	24,265	29,118
GA–512A	Third Seed Vessel Agitator (S.c.)	7,775	9,330
GA–513A	Fourth Seed Vessel Agitator (S.c.)	3,279	3,934
	Total ($ MM)	**1.82**	**2.39**
	TOTAL ($ MM)	11.37	17.68

14.69
5.94

17.68 +
3.19
20.87

DATE 08-Dec-94

600 ETHANOL RECOVERY

AS-602	**Rectification Column**	**0.59**	**1.78**
	Remaining Equipment		
AS-601	Beer Column	317,791	953,372
AS-640*	Vent Scrubber	159,887	479,661
T-601	Degasser Drum	43,374	60,723
T-602	Beer Column Reflux Drum	9,183	25,713
T-603	Fusel Oil Decanter	5,208	14,584
T-605	Rectification Column Reflux Drum	9,183	25,713
T-607*	Extraction Still Reflux Drum	9,183	25,713
T-630	Recycled Water Tank	23,590	54,258
pp-601	Beer Column Bottoms	82,244	115,141
pp-603	Beer Column Reflux	11,044	30,922
pp-604A/S	Wash Return	2,416	6,764
pp-605A/S	Fusel Oil	2,416	6,764
pp-607	Rectification Column Bottoms	2,772	7,761
pp-608	Rectification Column Reflux	20,729	58,042
pp-621	Ethanol Storage	2,066	5,785
pp-622	Bottoms to WWT	1,208	3,382
pp-631	Recycled Water	20,454	57,272
pp-632A/S	Sump	3,033	8,493
pp-641*	Vent Scrubber Return Ethanol	3,430	9,604
GS-611A/B	Sludge Screws	39,850	55,790
TT-607	Fusel Oil Cooler	1,222	2,567
TT-613	Mash Trim Heater	142,943	300,181
TT-615	Flash/Mash Exchanger	63,520	133,392
TT-616	Scrub/Flash Exchanger	23,864	50,113
TT-621	Beer Column Reboiler	174,677	366,822
TT-622	Beer Column Condenser/Rectification Column R	160,976	338,049
TT-623	Rectification Column O/H Condenser	77,836	163,456
TT-624	Beer Column O/H Trim. Condenser	37,797	79,375
TT-625	Beer Column Bottoms/Scrub Exchanger	4,150	8,714
TT-626	Rectification Column O/H Trim. Condenser	54,710	114,891
TT-627	Rectification Column Bottoms Trim Reboiler	41,592	87,343
TT-628	Beer Still Bottoms Trim Cooler	18,142	38,098
TT-629	Mash Beer Bottoms Exchanger	32,685	68,639
GC-609A/B/C	Centrifuge	713,340	927,342
FAN-640*	FAN	19,272	26,981
	Total ($ MM)	**2.34**	**4.71**
	TOTAL ($ MM)	**2.93**	**6.49**

700 OFF-SITE TANKAGE

T-701A/B	Ethanol Product Tank	669,242	936,938
T-703	Sulfuric Acid Storage Tank	119,564	143,477
T-704	Fire Water Tank	143,506	200,909
T-706A/B	NH3 Storage Tank	85,160	238,449
T-707	Antifoam Storage Tank	23,611	54,305
T-708	Diesel Fuel Tank	31,935	44,709
T-710	Gasoline Storage Tank	64,771	90,679
T-720	Corn Steep Liquor Tank	37,519	52,527
T-730*	Lime Slurry Storage Tank	112,590	135,108
pp-701A/B/S	Ethanol Export	13,535	37,898
pp-703A/S	Sulfuric Acid Transfer	8,492	16,983
pp-704 /S	Fire Water	17,897	50,111
pp-706A/S	NH3 Transfer	6,903	19,328
pp-707A/S	Antifoam Transfer	2,416	6,764
pp-708A/S	Diesel Fuel	3,284	9,195
pp-710A/S	Gasoline Blending	2,416	6,764
pp-720A/S	Corn Steep Liquor Transfer	8,079	16,158
GF-703	Desiccant Air Filter	41,004	57,405
	TOTAL ($ MM)	**1.39**	**2.12**

DATE 08-Dec-94

	800 WASTE TREATMENT		
MS-806	Offgas K.O. Suction Pot	13,179	30,311
MS-809	Offgas Knock Out Drum	13,179	30,311
MS-810	LP Vent Knock Out Drum	5,546	12,755
T-803	Equalization Tank	190,704	266,985
T-804	Anaerobic Reactor	983,412	1,376,777
T-807	Biotreater	1,190,392	1,666,548
800*	Pressure Swing Adsorption Oxygen Generator	528,245	633,894
pp-808A/S	Primary Heat Exchanger Influent Pump	3,538	9,907
pp-809A/S	Seconday Heat Exchanger Influent Pump	3,538	9,907
pp-813A*	Return Activated Sludge	7,182	14,363
pp-813B*	Waste Activated Sludge	5,174	10,348
pp-816A/S	Final Effluent	14,368	40,229
GS-801	Sludge Screws	29,046	40,664
new*	Bar Screens	59,085	70,902
TT-801	Offgas Cooler	15,667	32,901
TT-802	Feed Cooler(Primary Heat Exchanger)	54,981	115,460
TT-803A	Seconday Heat Exchanger A: Cooling Water	85,173	178,863
GC-801	Sludge Centrifuge	135,270	175,852
GO-806	Offgas Burner	21,136	25,363
GV-808	Secondary Clarifier	100,000	120,000
PB-810	Offgass Blower	78,520	109,928
PB-817A/S	LP Vent Blower	154,293	216,010
OSBL*	Equalization Tank Mixers	69,785	83,742
OSBL*	Nutrient Feed System	24,722	29,666
OSBL*	Anaerobic Mixers	353,331	423,997
OSBL*	Aeration Tank Mixers	115,644	138,773
OSBL*	Mist System and Backup Carbon	177,490	212,988
OSBL*	Biofilter	6,867	8,241
	TOTAL ($ MM)	**4.44**	**6.09**

DATE 08-Dec-94

900 UTILITIES

	Boiler Feed Water		
MS-902	Blowdown Flash Drum	5,825	16,309
MS-903	Hydrazine Drum	5,812	8,718
MS-904	Condensate Surge Drum	26,009	72,825
T-930	Condensate Collection Tank	50,231	80,369
pp-906A/S	Blowdown	3,284	9,195
pp-907	Hydrazine Transfer	1,950	3,900
pp-909A/S	Dearator Feed	10,941	30,634
pp-910A/S	Condensate	13,465	37,701
GU-903A/B	Demineralizers	651,412	781,694
GU-904A/S	Condensate Polisher	211,360	253,632
GU-907	Hydrazine Addition Package	15,852	19,022
GU-908	Ammonia Addition Package	15,852	19,022
GU-909	Phosphate Addition Package	15,852	19,022
GV-906	Dearator	140,554	393,552
pp-908A/S	Boiler Feed Water	111,307	155,829
HB-901A	Steam Boiler	18,999,998	24,699,997
	Total ($ MM)	**20.28**	**26.60**
	Process Water		
GF-901	Sand Filter	41,849	58,589
T-901	Process Water Tank	56,017	78,423
T-905	Backwash Transfer Tank	25,699	59,107
pp-902A/S	Process Water Transfer	19,748	55,294
pp-903A/S	Process Water Circulating	28,161	78,850
pp-904A/B	Backwash Feed	23,835	66,737
pp-905A/B	Backwash Transfer	2,930	8,203
pp-913A/S	Well Water	14,910	41,747
	Total ($ MM)	**0.21**	**0.45**
	Turbogenerator		
pp-901A/S	Turbine Condensate	10,080	28,224
GZ-911	Turbo Generator	6,116,113	9,174,169
	Total ($ MM)	**6.13**	**9.20**
	Cooling Water		
GT-912	Cooling Tower System	2,563,103	3,075,724
	Total ($ MM)	**2.56**	**3.08**
PK-951	**Chilled Water Package**	**1.02**	**1.23**
	Plant and Fermentation Air		
MS-906	Plant Air Receiver	19,945	55,845
MS-907	Instrument Air Receiver	19,945	55,845
GY-910	Instrument Air Dryer	24,412	34,177
PC-911	Air Compressor	55,258	71,835
PK-950A/B/S	Air Compressor Package(fermentation)	4,257,231	5,108,677
	Total ($ MM)	**4.38**	**5.33**
	CIP/CS		
T-961	Cleaning Tank	24,434	56,199
T-960	Sterilization Tank	40,458	60,686
T-963	Sterile Rinse Water Tank	24,434	56,199
pp-960A/S	Supply	4,660	9,321
pp-965A/B/C/S	CIP/CS Sump	4,831	13,528
GA-960	Sterilization Tank Agitator	12,417	14,900
GA-961	Cleanig Tank Agitator	12,417	14,900
Tank T-953	Sterile Water	40,458	60,686
pp-953	Sterile Water	1,950	3,900
TT-953	Water Sterilizer	3,410	7,162
	Total ($ MM)	**0.17**	**0.30**
	TOTAL ($ MM)	34.75	46.18
TOTAL		65.851681	94.18

26.60
9.20
35.80

0.45
3.08
1.23
5.33
0.30
10.39

0.45
3.08
1.23
5.33
0.30
10.39

DATE 08-Dec-94

EQUIPMENT COST BY SECTION

PLANT AREA	Chem Systems BASE EQUIPMENT COST ($ MM)	INSTALLED EQUIPMENT COST ($ MM)
ISBL		
100 WOOD HANDLING	2.48	3.20
200 PREHYDROLYSIS	5.19	7.75
300 XYLOSE FERMENTATION	2.28	3.19
400 CELLULASE PRODUCTION	1.03	1.50
500 SSF	11.37	17.68
600 ETHANOL RECOVERY	2.93	6.49
Total	**25.27**	**39.80**
OSBL		
700 OFF-SITE TANKAGE	1.39	2.12
800 WASTE TREATMENT	4.44	6.09
900 UTILITIES		
Boiler Feed Water and Boiler Package	20.28	26.60
Process Water	0.21	0.45
Turbogenerator	6.13	9.20
Cooling Water	2.56	3.08
Chilled Water Package	1.02	1.23
Plant and Fermentation Air	4.38	5.33
CIP/CS	0.17	0.30
BUILDINGS		1.59
SITE DEVELOPMENT		3.58
ADDITIONAL PIPING		1.79
Total	**40.58**	**61.35**
Total Equipment Cost	**65.85**	**101.15**
Proratable Costs		10.11
Field Expenses		10.11
Home Office Construction and Fee		25.29
Contingency		3.03
Total Fixed Capital Investment		**149.70**
Owner's Cost		14.97
Total Capital Investment		**164.67**

164.67
.05
823.35

164.67
8.23
172.90

26.60
9.20
35.80

61.35
35.80
25.55

25.55
2.12
23.43
6.09
23.34

Table A.VI.2
Physical Property Data, Liquids

Component	Formula	MW	Density @298K kg/m³	Cp @298K J/(kg·K)	Boiling Pt. °C	Heat of Vaporiz. J/kmol	Heat of Formation J/kmol	Gibbs Energy J/kmol	Source
Acetaldehyde	C2H4O	44.053	774	2556	20.8	2.57E+07	-1.66E+08	-1.29E+08	13
Ethanol	C2H5OH	46.069	787	2432	78.3	3.88E+07	-2.34E+08	-1.68E+08	13
Furfural	C5H4O2	96.086	1155	1698	161.7		-1.51E+08	-1.03E+08	13
Fusel Oils[1]	C5H12O	88.15	812	2388	131.2	4.41E+07	-3.02E+08	-1.45E+08	13
Glycerol	C3H8O3	92.095	1257	2376	290	6.11E+07	-5.83E+08	-4.49E+08	13
HMF	C6H6O3	126.1	1206		114.85	5.18E+07	-3.64E+08	-2.38E+08	12, 13[2]
Water	H2O	18.013	994	4187	100	4.07E+07	-2.42E+08	-2.29E+08	13

Notes:
(1) Fusel Oils are considered to be 100% isoamyl alcohol (3-methyl-1-butanol).
(2) Some data calculcated from UNIFAC contribution method.

Biomass to Ethanol Process Evaluation

Appendix

A report prepared for
National Renewable Energy Laboratory
December 1994

CHEM SYSTEMS

Chem Systems Inc.
303 South Broadway
Tarrytown, New York 10591
Telephone: (914) 631-2828 Telex: 221844 Facsimile (914) 631-8851

APPENDICES

APPENDIX I
MATERIAL BALANCE

Job Name: ALL-BAS

Date: 07-07-94 Time: 14:10

FLOWSHEET SUMMARY

Equipment		Label	Stream Numbers
1	PUMP	PP-201	212 -2101
2	MIXE	GA-201	211 2101 -2102
3	MIXE	MR-201	101 2102 213 -2103
4	CONT	100°C	2103 -102
5	MIXE		102 214 -2104
6	EREA	MR-202	2104 -215
7	CONT	160°C	215 -2105
8	CONT	H2SO4	2105 -2106
9	FLAS	T-203	2106 -2107 -2108
10	CSEP	T-203	2107 -216 -2109
11	MIXE	(T-203)	2109 2108 217 -2110
12	PUMP	PP-202	2110 -218
13	MIXE	(T-206)	218 221 -2201
14	EREA	T-206	2201 -2202
15	CONT	LIME	2202 -2203
16	FLAS	(T-206)	2203 -2204 -222
17	PUMP	PP-203	222 -2205
18	HTXR	TT-220	2205 -2206
19	DIVI		2206 -223 -224
20	HTXR	TT-301A	3101 -3102
21	DIVI		223 -302 -301
22	MIXE		3104 3103 3102 3121 302 -3105
23	PUMP	GA-305/10	3105 -3106
24	CONT	WORK	3106 -3116
25	EREA	FM-305/10	3116 -3107
26	HTXR	COILS	3122 -3108
27	FLAS		3108 -3109 -3110
28	CSEP		3110 -3111 -3115
29	MIXE		3111 3109 -3112
30	CSEP		3112 -3113 -3114
31	MIXE		3114 3115 -303
32	MIXE		305 303 301 -304
33	PUMP	GA-303	304 -3117
34	CONT	WORK	3117 -3118
35	EREA	FM-303	3118 -3119
36	HTXR	COILS	3123 -3120
37	FLAS	(FM-303)	3120 -307 -306
38	PUMP	PP-303	306 -308
39	DIVI		224 -412 -411
40	HTXR	TT-401A	4101 -4102
41	HTXR	TT-401B	4102 -4103
42	MIXE		4105 4134 4104 4103 412 -4106
43	PUMP	GA-401/4	4106 -4107
44	CONT	work	4107 -4108
45	EREA	FM-401/4	4108 -4109
46	HTXR	COILS	4135 -4110

47	FLAS		4110 -4111 -4112
48	CSEP		4112 -4114 -4115
49	MIXE		4114 4111 -4116
50	CSEP		4116 -4113 -4117
51	MIXE		4117 4115 -413
52	HTXR	TT-402A	4118 -4119
53	HTXR	TT-402B	4119 -414
54	MIXE		413 411 415 416 418 414 -4120
55	PUMP	GA-400	4120 -4121
56	CONT	WORK	4121 -4122
57	EREA	FM-400	4122 -4123
58	EREA	FM-400	4123 -4124
59	CONT	NH3	4124 -4125
60	HTXR	COILS	4125 -4126
61	FLAS		4126 -4127 -4128
62	CSEP		4127 -4130 -4129
63	MIXE		4129 4128 -4131
64	CSEP		4131 -4132 -4133
65	MIXE		4132 4130 -419
66	PUMP	PP-412	4133 -420
67	DIVI		420 -5101 -5102
68	DIVI		308 -5103 -5104
69	MIXE		5101 5103 -501
70	MIXE		5107 5106 5105 5133 501 -5108
71	PUMP	GA-501/6	5108 -5109
72	CONT	WORK	5109 -5110
73	EREA	FM-501/6	5110 -5111
74	CONT	NH3	5111 -5112
75	HTXR	COILS	5112 -5113
76	FLAS		5113 -5114 -5115
77	CSEP		5115 -5116 -5117
78	MIXE		5116 5114 -5119
79	CSEP		5119 -5118 -5120
80	MIXE		5120 5117 -502
81	MIXE		502 5104 5102 -503
82	PUMP	GA-500	503 -5121
83	CONT	WORK	5121 -5122
84	EREA	FM-500	5135 -5123
85	EREA	FM-500	5123 -5124
86	HTXR	COILS	5136 -5125
87	FLAS		5125 -5126 -5127
88	CSEP		5126 -5131 -5128
89	MIXE		5128 5127 -5129
90	CSEP		5129 -5130 -5132
91	MIXE		5130 5131 -508
92	PUMP	PP-505	5132 -510
93	HTXR	TT-615	510 216 -6102 -6101
94	HTXR	TT-613	6102 -6103
95	FLAS	T-601	6103 -6104 -6105
96	CSEP		6105 -6110 -6107
97	HTXR	(REBOILER)	6107 -6108
98	MIXE		307 5118 508 6104 -6109
99	CSEP		6110 -6302 -6106
100	MIXE		6208 6304 -6305
101	MIXE		6108 611 -6301
102	CSEP	GC-609	6301 -6303 -6308
103	CONT	LIGNIN CONC	6308 -631

104	PUMP	PP-631	6303 -6304
105	MIXE		632 634 6306 -6307
108	DIVI		6305 -211 -217 -3101 -4101 -4118 -633
109	PUMP	PP-801	6101 -8101
110	MIXE	T-803	8102 8101 633 -8103
111	PUMP	PP-808	8103 -8104
112	HTXR	TT-802	8104 -8105
113	EREA	T-804	8105 -8106
114	EREA	T-804	8106 -8107
115	FLAS	(T-804)	8108 -8110 -8109
116	PUMP	PP-809	8109 -812
117	MIXE	GV-807	8201 812 -8203
118	EREA	T-807	8203 -8204
119	FLAS		8205 -8206 -8207
120	CSEP	GV-808	8207 -8208 -821
121	PUMP	PP-816	8208 -822
122	CONT	NH3	3107 -3122
123	CONT	NH3	3119 -3123
124	CONT	NH3	4109 -4135
125	CONT	NH3	8107 -8108
126	MIXE		5122 5134 -5135
127	CONT	NH3	5124 -5136
128	COMP	PB-810	8110 -813
130	CONT	oxygen	8204 -8205

Stream Connections

Stream	Equipment From	To	Stream	Equipment From	To	Stream	Equipment From	To
101		3	3104		22	5110	72	73
102	4	5	3105	22	23	5111	73	74
211	108	2	3106	23	24	5112	74	75
212		1	3107	25	122	5113	75	76
213		3	3108	26	27	5114	76	78
214		5	3109	27	29	5115	76	77
215	6	7	3110	27	28	5116	77	78
216	10	93	3111	28	29	5117	77	80
217	108	11	3112	29	30	5118	79	98
218	12	13	3113	30		5119	78	79
221		13	3114	30	31	5120	79	80
222	16	17	3115	28	31	5121	82	83
223	19	21	3116	24	25	5122	83	126
224	19	39	3117	33	34	5123	84	85
301	21	32	3118	34	35	5124	85	127
302	21	22	3119	35	123	5125	86	87
303	31	32	3120	36	37	5126	87	88
304	32	33	3121		22	5127	87	89
305		32	3122	122	26	5128	88	89
306	37	38	3123	123	36	5129	89	90
307	37	98	4101	108	40	5130	90	91
308	38	68	4102	40	41	5131	88	91
411	39	54	4103	41	42	5132	90	92
412	39	42	4104		42	5133		70
413	51	54	4105		42	5134		126
414	53	54	4106	42	43	5135	126	84
415		54	4107	43	44	5136	127	86

416		54	4108	44	45	6101	93	109
418		54	4109	45	124	6102	93	94
419	65		4110	46	47	6103	94	95
420	66	67	4111	47	49	6104	95	98
501	69	70	4112	47	48	6105	95	96
502	80	81	4113	50		6106	99	
503	81	82	4114	48	49	6107	96	97
508	91	98	4115	48	51	6108	97	101
510	92	93	4116	49	50	6109	98	
611		101	4117	50	51	6110	96	99
631	103		4118	108	52	6208		100
632		105	4119	52	53	6301	101	102
633	108	110	4120	54	55	6302	99	
634		105	4121	55	56	6303	102	104
812	116	117	4122	56	57	6304	104	100
813	128		4123	57	58	6305	100	108
821	120		4124	58	59	6306		105
822	121		4125	59	60	6307	105	
2101	1	2	4126	60	61	6308	102	103
2102	2	3	4127	61	62	8101	109	110
2103	3	4	4128	61	63	8102		110
2104	5	6	4129	62	63	8103	110	111
2105	7	8	4130	62	65	8104	111	112
2106	8	9	4131	63	64	8105	112	113
2107	9	10	4132	64	65	8106	113	114
2108	9	11	4133	64	66	8107	114	125
2109	10	11	4134		42	8108	125	115
2110	11	12	4135	124	46	8109	115	116
2201	13	14	5101	67	69	8110	115	128
2202	14	15	5102	67	81	8201		117
2203	15	16	5103	68	69	8203	117	118
2204	16		5104	68	81	8204	118	130
2205	17	18	5105		70	8205	130	119
2206	18	19	5106		70	8206	119	
3101	108	20	5107		70	8207	119	120
3102	20	22	5108	70	71	8208	120	121
3103		22	5109	71	72			

Equipment Calculation Sequence

1	105	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
18	19	39	21	22	23	24	25	122	26	27	28	29	30	31	32	33	34
35	123	36	37	38	68	42	43	44	45	124	46	47	48	49	50	51	54
55	56	57	58	59	60	61	62	63	64	66	67	69	70	71	72	73	74
75	76	77	78	79	80	81	82	83	126	84	85	127	86	87	88	89	90
92	93	94	95	96	97	101	102	104	100	108	40	20	52	53	41	65	91
98	99	103	109	110	111	112	113	114	125	115	116	117	118	128	130	119	120
121																	

Equipment Recycle Sequence

2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
39	21	22	23	24	25	122	26	27	28	29	30	31	32	33	34	35	123
36	37	38	68	42	43	44	45	124	46	47	48	49	50	51	54	55	56
57	58	59	60	61	62	63	64	66	67	69	70	71	72	73	74	75	76
77	78	79	80	81	82	83	126	84	85	127	86	87	88	89	90	92	93
94	95	96	97	101	102	104	100	108	40	20	52	53	41				

Recycle Cut Streams
211 217 3102 4103 414

Recycle Convergence Method: Direct Substitution

Max. loop iterations 40

Recycle Convergence Tolerance

Flow rate	**1.000E-003**
Temperature	**1.000E-003**
Pressure	**1.000E-003**
Enthalpy	**1.000E-003**
Vapor frac.	**1.000E-003**

Recycle calculation has converged.

COMPONENTS

	ID #	Name	
1	62	Water	
2	8003	Cellulose	* solid *
3	8004	Xylan	
4	8008	Arabinan	
5	8009	Mannan	
6	8010	Galacatan	
7	776	Alpha-D-Glucose	* solid *
8	8001	Xylose	
9	8005	Arabinose	
10	8006	Mannose	
11	8007	Galactose	
12	134	Ethanol	
13	8002	HMF	
14	164	Furfural	
15	931	Calcium Sulfate	* solid *
16	268	Glycerol	
17	8011	Lignin	* solid *
18	8016	Soluble Solids	
19	8013	Ash	
20	8014	Cell Mass	
21	431	Sulfuric Acid	
22	929	CalciumHydroxide	* solid *
23	8015	Cellulase	
24	475	Air	
25	46	Nitrogen	
26	47	Oxygen	
27	49	Carbon Dioxide	
28	128	Acetaldehyde	
29	315	3-Mth-1-Butanol	
30	2	Methane	
31	63	Ammonia	

THERMODYNAMICS

K-value model : NRTL
No corrrection for vapor fugacity
Enthalpy model : Mixed Model
Liquid density : Library

NRTL Parameters:

I	J	Bij	Bji	Alpha
1	12	670.441	-55.168	0.303
1	13	2499.992	736.815	0.200
1	14	1584.604	-204.266	0.202
~~1~~	~~16~~	~~258.114~~	~~-274.349~~	~~1.011~~
1	21	-1228.663	-1894.248	0.243
1	28	662.993	-23.571	0.287
1	29	1828.452	-249.014	0.282
12	14	510.442	328.316	0.777
12	16	398.444	79.505	0.296
12	28	195.116	-553.744	0.409
12	29	25.750	-21.569	0.301
13	14	41.636	2499.960	0.312
13	16	1348.007	2499.989	0.200
14	16	1411.930	-16.983	0.350
30	31	-0.131	237.017	0.000

Warning : BIP matrix is less than 50 % full.

1- Water
12 - EtOH
13 - HMF
14- Furfural
16- Glycerol
21- H_2SO_4
28 - Acetaldehyde
29 - 3-Meth-1 Butanol
30 - methane
31 - Ammonia

Overall Mass Balance	kmol/h		kg/h	
	Input	Output	Input	Output
Water	30957.424	30772.947	557697.976	554374.616
Cellulose	206.755	23.613	33523.877	3828.750
Xylan	99.136	1.328	13097.531	175.467
Arabinan	7.415	0.099	979.594	13.124
Mannan	15.932	0.576	2583.225	93.416
Galacatan	4.654	0.168	754.650	27.290
Alpha-D-Glucose	2.553	0.000	460.000	0.000
Xylose	0.000	0.613	0.008	91.987
Arabinose	0.000	0.046	0.001	6.853
Mannose	0.000	0.000	0.000	0.000
Galactose	0.000	0.000	0.000	0.000
Ethanol	0.239	470.738	11.000	21686.409
HMF	0.000	0.020	0.000	2.563
Furfural	24.426	25.956	2347.002	2494.013
Calcium Sulfate	0.000	11.776	0.001	1603.148
Glycerol	106.054	109.658	9767.040	10098.912
Lignin	142.396	142.412	17415.002	17417.037
Soluble Solids	2.456	2.425	4063.501	4011.751
Ash	1.187	1.187	145.125	145.142
Cell Mass	0.008	1.143	17.804	2643.384
Sulfuric Acid	11.774	0.000	1154.799	0.000
CalciumHydroxide	11.818	0.044	875.634	3.249
Cellulase	0.000	0.000	0.002	0.026
Air	2114.594	1842.167	61219.612	53332.573
Nitrogen	0.000	216.654	0.000	6069.338
Oxygen	23.438	49.433	750.000	1581.820
Carbon Dioxide	0.000	596.674	0.000	26259.615
Acetaldehyde	0.000	0.860	0.000	37.874
3-Mth-1-Butanol	0.000	0.172	0.000	15.157
Methane	0.000	88.756	0.000	1423.905
Ammonia	38.765	0.335	660.203	5.712
Total	33771.026	34359.806	707523.641	707443.129

EQUIPMENT SUMMARIES

Pump Summary

Equip. No.	1	12	17	23
Name	PP-201	PP-202	PP-203	GA-305/10
Output pressure Pa		207000.0000		
Pressure increase Pa	965000.0000		414000.0000	218.5615
Efficiency	0.7500	0.7500	0.7500	1.0000e-004
Calculated power kW	0.2250	16.6910	69.7433	61.8021

Equip. No.	33	38	43	55
Name	GA-303	PP-303	GA-401/4	GA-400
Pressure increase Pa	83.9075	345000.0000	1798.3339	1652.2672
Efficiency	1.0000e-004	0.7500	1.0000e-004	1.0000e-004
Calculated power kW	105.7098	58.0723	8.6300	528.0167

Equip. No.	66	71	82	92
Name	PP-412	GA-501/6	GA-500	PP-505
Pressure increase Pa	412000.0000	1069.5040	1115.3357	412000.0000
Efficiency	0.7500	1.0000e-004	1.0000e-004	0.7500
Calculated power kW	3.6010	417.0361	1485.2222	72.3874

Equip. No.	104	109	111	116
Name	PP-631	PP-801	PP-808	PP-809
Output pressure Pa	452000.0000			
Pressure increase Pa		100000.0000	303000.0000	303000.0000
Efficiency	0.8500	0.8500	0.8500	0.8500
Calculated power kW	49.3492	0.6155	12.9385	12.0557

Equip. No.	121
Name	PP-816
Output pressure Pa	452000.0000
Efficiency	0.8500
Calculated power kW	13.8096

Mixer Summary

Equip. No.	2	3	5	11
Name	GA-201	MR-201		(T-203)
Output Pressure Pa	532000.0000	446062.0312	1.1355e+006	108000.0000

Equip. No.	13	22	29	31
Name	(T-206)			
Output Pressure Pa	108000.0000	108000.0000	108000.0000	108000.0000

Equip. No.	32	42	49	51
Name				
Output Pressure Pa	108000.0000	432000.0000	108000.0000	108000.0000

Equip. No.	54	63	65	69
Name				
Output Pressure Pa	108000.0000	108000.0000	108000.0000	108000.0000

Equip. No.	70	78	80	81

EQUIPMENT SUMMARIES

Name				
Output Pressure Pa	108000.0000	108000.0000	108000.0000	108000.0000
Equip. No.	89	91	98	100
Name				
Output Pressure Pa	108000.0000	108000.0000	108000.0000	452000.0000
Equip. No.	101	105	110	117
Name			T-803	GV-807
Output Pressure Pa	108000.0000		108000.0000	102000.0000
Equip. No.	126			
Name				

Controller Summary

Equip. No.	4	7	8	15
Name	100°C	160°C	H2SO4	LIME
Mode:	2	2	2	2
Stream no. adjusted	213	214	212	221
Variable No.	6	6	6	6
Beginning	0	0	0	0
Measured variables:				
Number	2103	215	215	2202
Variable	1	1	-21	-21
Operator	0	0	4	1
Number	0	0	215	2202
Variable	0	0	-1	-22
Constant	100.0000	160.0000	0.0016	0.1000
Units	2	2	0	0
Equip. No.	24	34	44	56
Name	WORK	WORK	work	WORK
Mode:	2	2	2	2
Equip. no. adjusted	23	33	43	55
Variable No.	3	3	3	3
Beginning	0	0	0	0
Measured variables:				
Type:	1	1	1	1
Number	23	33	43	55
Variable	5	5	5	5
Constant	61.8000	105.7000	8.6300	528.0000
Units	7	7	7	7
Equip. No.	59	72	74	83
Name	NH3	WORK	NH3	WORK
Mode:	2	2	2	2
Equip. no. adjusted	0	71	0	82
Stream no. adjusted	416	0	5133	0
Variable No.	6	3	6	3
Beginning	0	0	0	0

EQUIPMENT SUMMARIES

Measured variables:				
Type:	0	1	0	1
Number	4124	71	5111	82
Variable	-31	5	-31	5
Constant	0.0100	417.0000	0.0100	1485.0000
Units	0	7	0	7

Equip. No.	103	122	123	124
Name	LIGNIN CONC	NH3	NH3	NH3
Mode:	2	2	2	2
Equip. no. adjusted	102	0	0	0
Stream no. adjusted	0	3121	305	4134
Variable No.	10	6	6	6
Beginning	0	0	0	0
Measured variables:				
Number	6308	3107	3119	4109
Variable	-17	-31	-31	-31
Scale	122.3000			
Operator	4	0	0	0
Number	6308	0	0	0
Variable	6	0	0	0
Constant	0.4000	0.0100	0.0100	0.0100

Equip. No.	125	127	130
Name	NH3	NH3	oxygen
Mode:	2	2	0
Stream no. adjusted	8102	5134	8201
Variable No.	6	6	6
Beginning	0	0	0
Measured variables:			
Number	8107	5124	8204
Variable	-31	-31	-26
Operator	0	0	4
Number	0	0	8203
Variable	0	0	-26
Constant	0.0100	0.0100	0.5000

Equilibrium Reactor Summary

Equip. No.	6	14	25	35
Name	MR-202	T-206	FM-305/10	FM-303
No of Reactions	10	1	5	5
Specify thermal mode:	1	1	1	1
C	159.9985	101.9518	49.9741	57.2015
Temperature Units:	3	3	3	3
Pressure Units:	7	7	7	7
Heat of Reaction Units:	4	3	4	4
Molar Flow Units:	1	1	1	1
Reference Temp C	15.0000			15.0000
Calc Overall Ht of Rxn (kW)	-1937.7831	-1869.8578	-1756.6875	-13439.2695

EQUIPMENT SUMMARIES

Reaction Stoichiometrics and Parameters for unit no. 6

Reaction no.	1	2	3	4
Base component	2	5	6	2
Frac.conversion	0.0300	0.8000	0.8000	0.0010
	2	5	6	2
	-1.0000	-1.0000	-1.0000	-1.0000
	1.0000	1.0000	1.0000	1.0000
	1	1	1	13
	-1.0000	-1.0000	-1.0000	1.0000
	1.0000	1.0000	1.0000	1.0000
	7	10	11	1
	1.0000	1.0000	1.0000	2.0000
	1.0000	1.0000	1.0000	1.0000
Reaction no.	5	6	7	8
Base component	5	6	3	4
Frac.conversion	0.0010	0.0010	0.8000	0.8000
	5	6	3	4
	-1.0000	-1.0000	-1.0000	-1.0000
	1.0000	1.0000	1.0000	1.0000
	13	13	1	1
	1.0000	1.0000	-1.0000	-1.0000
	1.0000	1.0000	1.0000	1.0000
	1	1	8	9
	2.0000	2.0000	1.0000	1.0000
	1.0000	1.0000	1.0000	1.0000
Reaction no.	9	10		
Base component	3	4		
Frac.conversion	0.1300	0.1300		
	3	4		
	-1.0000	-1.0000		
	1.0000	1.0000		
	14	14		
	1.0000	1.0000		
	1.0000	1.0000		
	1	1		
	2.0000	2.0000		
	1.0000	1.0000		

Reaction Stoichiometrics and Parameters for unit no. 14

Reaction no.	1
Base component	21
Frac.conversion	1.0000
	21
	-1.0000
	1.0000
	22
	-1.0000
	1.0000
	1
	2.0000
	1.0000
	15

EQUIPMENT SUMMARIES

	1.0000
	1.0000

Reaction Stoichiometrics and Parameters for unit no. 25

Reaction no.	1	2	3	4
Base component	7	10	11	8
Heat of reaction	-1.0800e+006	-1.0800e+006	-1.0800e+006	-1.0600e+006
Frac.conversion	1.0000	1.0000	1.0000	1.0000
	7	10	11	8
	-100.0000	-100.0000	-100.0000	-100.0000
	1.0000	1.0000	1.0000	1.0000
	24	24	24	24
	-919.0000	-919.0000	-919.0000	-771.0000
	1.0000	1.0000	1.0000	1.0000
	31	31	31	31
	-89.7000	-89.7000	-89.7000	-74.7000
	1.0000	1.0000	1.0000	1.0000
	20	20	20	20
	3.9000	3.9000	3.9000	3.2500
	1.0000	1.0000	1.0000	1.0000
	27	27	27	27
	210.0000	210.0000	210.0000	175.0000
	1.0000	1.0000	1.0000	1.0000
	1	1	1	1
	415.0000	415.0000	415.0000	346.0000
	1.0000	1.0000	1.0000	1.0000
	25	25	25	25
	726.0000	726.0000	726.0000	609.0000
	1.0000	1.0000	1.0000	1.0000

Reaction no.	5
Base component	9
Heat of reaction	-1.0600e+006
Frac.conversion	1.0000
	9
	-100.0000
	1.0000
	24
	-771.0000
	1.0000
	31
	-74.7000
	1.0000
	20
	3.2500
	1.0000
	27
	175.0000
	1.0000
	1
	346.0000
	1.0000
	25
	609.0000
	1.0000

EQUIPMENT SUMMARIES

Reaction Stoichiometrics and Parameters for unit no. 35

Reaction no.	1	2	3	4
Base component	7	10	11	8
Heat of reaction				-620000.0000
Frac.conversion	0.8550	0.8550	0.8550	0.8550
	7	10	11	8
	-1.0000	-1.0000	-1.0000	-3.0000
	1.0000	1.0000	1.0000	1.0000
	12	12	12	12
	2.0000	2.0000	2.0000	5.0000
	1.0000	1.0000	1.0000	1.0000
	27	27	27	27
	2.0000	2.0000	2.0000	5.0000
	1.0000	1.0000	1.0000	1.0000
Reaction no.	5			
Base component	9			
Heat of reaction	-620000.0000			
Frac.conversion	0.8550			
	9			
	-3.0000			
	1.0000			
	12			
	5.0000			
	1.0000			
	27			
	5.0000			
	1.0000			

Equip. No.	45	57	58	73
Name	FM-401/4	FM-400	FM-400	FM-501/6
No of Reactions	8	8	8	6
Specify thermal mode:	1	1	1	1
C	67.0654	37.9038	59.1862	47.6848
Temperature Units:	3	3	3	3
Pressure Units:	6	7	7	7
Heat of Reaction Units:	3	3	3	3
Molar Flow Units:	1	1	1	1
Reference Temp C	15.0000	15.0000	15.0000	15.0000
Calc Overall Ht of Rxn (kW)	-11.2205	-453.9841	-2228.8594	-1265.0203

Reaction Stoichiometrics and Parameters for unit no. 45

Reaction no.	1	2	3	4
Base component	7	10	11	8
Heat of reaction				-1.0600e+006
Frac.conversion	1.0000	1.0000	1.0000	1.0000
	7	10	11	8
	-100.0000	-100.0000	-100.0000	-100.0000
	1.0000	1.0000	1.0000	1.0000
	24	24	24	24
	-919.0000	-919.0000	-919.0000	-771.0000

EQUIPMENT SUMMARIES

	1.0000	1.0000	1.0000	1.0000
	31	31	31	31
	-89.7000	-89.7000	-89.7000	-74.7000
	1.0000	1.0000	1.0000	1.0000
	20	20	20	20
	3.9000	3.9000	3.9000	3.2500
	1.0000	1.0000	1.0000	1.0000
	27	27	27	27
	210.0000	210.0000	210.0000	175.0000
	1.0000	1.0000	1.0000	1.0000
	1	1	1	1
	415.0000	415.0000	415.0000	346.0000
	1.0000	1.0000	1.0000	1.0000
	25	25	25	25
	726.0000	726.0000	726.0000	609.0000
	1.0000	1.0000	1.0000	1.0000
Reaction no.	5	6	7	8
Base component	9	2	5	6
Heat of reaction	-1.0600e+006			
Frac.conversion	1.0000	1.0000	1.0000	1.0000
	9	2	5	6
	-100.0000	-100.0000	-100.0000	-100.0000
	1.0000	1.0000	1.0000	1.0000
	24	24	24	24
	-771.0000	-1114.0000	-1114.0000	-1114.0000
	1.0000	1.0000	1.0000	1.0000
	31	31	31	31
	-74.7000	-80.6000	-80.6000	-80.6000
	1.0000	1.0000	1.0000	1.0000
	20	20	20	20
	3.2500	3.5100	3.5100	3.5100
	1.0000	1.0000	1.0000	1.0000
	27	27	27	27
	175.0000	249.0000	249.0000	249.0000
	1.0000	1.0000	1.0000	1.0000
	1	1	1	1
	346.0000	333.0000	333.0000	333.0000
	1.0000	1.0000	1.0000	1.0000
	25	25	25	25
	609.0000	880.0000	880.0000	880.0000
	1.0000	1.0000	1.0000	1.0000

Reaction Stoichiometrics and Parameters for unit no. 57

Reaction no.	1	2	3	4
Base component	7	10	11	8
Heat of reaction				-1.0800e+006
Frac.conversion	0.3250	0.3250	0.3250	0.3250
	7	10	11	8
	-100.0000	-100.0000	-100.0000	-100.0000
	1.0000	1.0000	1.0000	1.0000
	24	24	24	24
	-919.0000	-919.0000	-919.0000	-771.0000
	1.0000	1.0000	1.0000	1.0000
	31	31	31	31

EQUIPMENT SUMMARIES

	-89.7000	-89.7000	-89.7000	-74.7000
	1.0000	1.0000	1.0000	1.0000
	20	20	20	20
	3.9000	3.9000	3.9000	3.2500
	1.0000	1.0000	1.0000	1.0000
	27	27	27	27
	210.0000	210.0000	210.0000	175.0000
	1.0000	1.0000	1.0000	1.0000
	1	1	1	1
	415.0000	415.0000	415.0000	346.0000
	1.0000	1.0000	1.0000	1.0000
	25	25	25	25
	726.0000	726.0000	726.0000	609.0000
	1.0000	1.0000	1.0000	1.0000
Reaction no.	5	6	7	8
Base component	9	2	5	6
Heat of reaction	-1.0800e+006			
Frac.conversion	0.3250	0.3250	0.3250	0.3250
	9	2	5	6
	-100.0000	-100.0000	-100.0000	-100.0000
	1.0000	1.0000	1.0000	1.0000
	24	24	24	24
	-771.0000	-1114.0000	-1114.0000	-1114.0000
	1.0000	1.0000	1.0000	1.0000
	31	31	31	31
	-74.7000	-80.6000	-80.6000	-80.6000
	1.0000	1.0000	1.0000	1.0000
	20	20	20	20
	3.2500	3.5100	3.5100	3.5100
	1.0000	1.0000	1.0000	1.0000
	27	27	27	27
	175.0000	249.0000	249.0000	249.0000
	1.0000	1.0000	1.0000	1.0000
	1	1	1	1
	346.0000	333.0000	333.0000	333.0000
	1.0000	1.0000	1.0000	1.0000
	25	25	25	25
	609.0000	880.0000	880.0000	880.0000
	1.0000	1.0000	1.0000	1.0000

Reaction Stoichiometrics and Parameters for unit no. 58

Reaction no.	1	2	3	4
Base component	2	5	6	7
Frac.conversion	1.0000	1.0000	1.0000	1.0000
	2	5	6	7
	-100.0000	-100.0000	-100.0000	-100.0000
	1.0000	1.0000	1.0000	1.0000
	24	24	24	24
	-1895.0000	-1895.0000	-1895.0000	-1895.0000
	1.0000	1.0000	1.0000	1.0000
	31	31	31	31
	-57.4000	-57.4000	-57.4000	-57.4000
	1.0000	1.0000	1.0000	1.0000
	23	23	23	23

EQUIPMENT SUMMARIES

	1.9800	1.9800	1.9800	1.9800
	1.0000	1.0000	1.0000	1.0000
	27	27	27	27
	402.0000	402.0000	402.0000	402.0000
	1.0000	1.0000	1.0000	1.0000
	1	1	1	1
	431.0000	431.0000	431.0000	531.0000
	1.0000	1.0000	1.0000	1.0000
	25	25	25	25
	1497.0000	1497.0000	1497.0000	1497.0000
	1.0000	1.0000	1.0000	1.0000
Reaction no.	5	6	7	8
Base component	10	11	8	9
Heat of reaction			-1.5600e+006	-1.5600e+006
Frac.conversion	1.0000	1.0000	1.0000	1.0000
	10	11	8	9
	-100.0000	-100.0000	-100.0000	-100.0000
	1.0000	1.0000	1.0000	1.0000
	24	24	24	24
	-1895.0000	-1895.0000	-1490.0000	-1490.0000
	1.0000	1.0000	1.0000	1.0000
	31	31	31	31
	-57.4000	-57.4000	-53.1000	-53.1000
	1.0000	1.0000	1.0000	1.0000
	23	23	23	23
	1.9800	1.9800	1.8300	1.8300
	1.0000	1.0000	1.0000	1.0000
	27	27	27	27
	402.0000	402.0000	317.0000	317.0000
	1.0000	1.0000	1.0000	1.0000
	1	1	1	1
	531.0000	531.0000	436.0000	436.0000
	1.0000	1.0000	1.0000	1.0000
	25	25	25	25
	1497.0000	1497.0000	1177.0000	1177.0000
	1.0000	1.0000	1.0000	1.0000

Reaction Stoichiometrics and Parameters for unit no. 73

Reaction no.	1	2	3	4
Base component	7	10	11	2
Frac.conversion	1.0000	1.0000	1.0000	0.1460
	7	10	11	2
	-100.0000	-100.0000	-100.0000	-100.0000
	1.0000	1.0000	1.0000	1.0000
	24	24	24	24
	-919.0000	-919.0000	-919.0000	-1114.0000
	1.0000	1.0000	1.0000	1.0000
	31	31	31	31
	-89.7000	-89.7000	-89.7000	-234.0000
	1.0000	1.0000	1.0000	1.0000
	20	20	20	20
	3.9000	3.9000	3.9000	3.5100
	1.0000	1.0000	1.0000	1.0000
	27	27	27	27

EQUIPMENT SUMMARIES

	210.0000	210.0000	210.0000	249.0000
	1.0000	1.0000	1.0000	1.0000
	1	1	1	1
	415.0000	415.0000	415.0000	333.0000
	1.0000	1.0000	1.0000	1.0000
	25	25	25	25
	726.0000	726.0000	726.0000	880.0000
	1.0000	1.0000	1.0000	1.0000
Reaction no.	5	6		
Base component	5	6		
Frac.conversion	0.1460	0.1460		
	5	6		
	-100.0000	-100.0000		
	1.0000	1.0000		
	24	24		
	-1114.0000	-1114.0000		
	1.0000	1.0000		
	31	31		
	-80.6000	-80.6000		
	1.0000	1.0000		
	20	20		
	3.5100	3.5100		
	1.0000	1.0000		
	27	27		
	249.0000	249.0000		
	1.0000	1.0000		
	1	1		
	333.0000	333.0000		
	1.0000	1.0000		
	25	25		
	880.0000	880.0000		
	1.0000	1.0000		

Equip. No.	84	85	113	114
Name	FM-500	FM-500	T-804	T-804
No of Reactions	5	12	18	1
Specify thermal mode:	1	1	2	2
C	43.3789	48.1183	35.0000	35.0000
kW			3785.8560	796.6229
Temperature Units:	3	3	3	3
Pressure Units:	7	7	7	7
Heat of Reaction Units:	3	3	4	4
Molar Flow Units:	1	1	1	1
Reference Temp C	15.0000	15.0000	15.0000	15.0000
Calc Overall Ht of Rxn (kW)	-3361.5591	2074.9775	2166.8982	918.8409

Reaction Stoichiometrics and Parameters for unit no. 84

Reaction no.	1	2	3	4
Base component	2	5	6	3
Frac.conversion	0.8700	0.8000	0.8000	0.8000
	2	5	6	3
	-1.0000	-1.0000	-1.0000	-1.0000
	1.0000	1.0000	1.0000	1.0000

EQUIPMENT SUMMARIES

	1	1	1	1
	-1.0000	-1.0000	-1.0000	-1.0000
	1.0000	1.0000	1.0000	1.0000
	7	10	11	8
	1.0000	1.0000	1.0000	1.0000
	1.0000	1.0000	1.0000	1.0000
Reaction no.	5			
Base component	4			
Frac.conversion	0.8000			
	4			
	-1.0000			
	1.0000			
	1			
	-1.0000			
	1.0000			
	9			
	1.0000			
	1.0000			

Reaction Stoichiometrics and Parameters for unit no. 85

Reaction no.	1	2	3	4
Base component	7	10	11	7
Frac.conversion	0.9200	0.9200	0.9200	0.0050
	7	10	11	7
	-1.0000	-1.0000	-1.0000	-1.0000
	1.0000	1.0000	1.0000	1.0000
	12	12	12	16
	2.0000	2.0000	2.0000	1.0000
	1.0000	1.0000	1.0000	1.0000
	27	27	27	28
	2.0000	2.0000	2.0000	1.0000
	1.0000	1.0000	1.0000	1.0000
	0	0	0	27
				1.0000
				1.0000
Reaction no.	5	6	7	8
Base component	10	11	7	10
Frac.conversion	0.0050	0.0050	0.0010	0.0010
	10	11	7	10
	-1.0000	-1.0000	-1.0000	-1.0000
	1.0000	1.0000	1.0000	1.0000
	16	16	29	29
	1.0000	1.0000	1.0000	1.0000
	1.0000	1.0000	1.0000	1.0000
	28	28	27	27
	1.0000	1.0000	1.0000	1.0000
	1.0000	1.0000	1.0000	1.0000
	27	27	26	26
	1.0000	1.0000	1.5000	1.5000
	1.0000	1.0000	1.0000	1.0000
Reaction no.	9	10	11	12
Base component	11	7	10	11
Frac.conversion	0.0010	0.0740	0.0740	0.0740
	11	7	10	11

EQUIPMENT SUMMARIES

	-1.0000	-100.0000	-100.0000	-100.0000
	1.0000	1.0000	1.0000	1.0000
	29	12	12	12
	1.0000	-100.0000	-100.0000	-100.0000
	1.0000	1.0000	1.0000	1.0000
	27	31	31	31
	1.0000	-46.0000	-46.0000	-46.0000
	1.0000	1.0000	1.0000	1.0000
	26	20	20	20
	1.5000	2.0000	2.0000	2.0000
	1.0000	1.0000	1.0000	1.0000
	0	16	16	16
		200.0000	200.0000	200.0000
		1.0000	1.0000	1.0000
	0	1	1	1
		5.0000	5.0000	5.0000
		1.0000	1.0000	1.0000
	0	26	26	26
		8.5000	8.5000	8.5000
		1.0000	1.0000	1.0000

Reaction Stoichiometrics and Parameters for unit no. 113

Reaction no.	1	2	3	4
Base component	2	5	6	3
Frac.conversion	0.9000	0.9000	0.9000	0.9000
	2	5	6	3
	-1.0000	-1.0000	-1.0000	-2.0000
	1.0000	1.0000	1.0000	1.0000
	1	1	1	1
	-1.0000	-1.0000	-1.0000	-2.0000
	1.0000	1.0000	1.0000	1.0000
	27	27	27	27
	3.0000	3.0000	3.0000	5.0000
	1.0000	1.0000	1.0000	1.0000
	30	30	30	30
	3.0000	3.0000	3.0000	5.0000
	1.0000	1.0000	1.0000	1.0000
Reaction no.	5	6	7	8
Base component	4	7	10	11
Frac.conversion	0.9000	0.9000	0.9000	0.9000
	4	7	10	11
	-2.0000	-1.0000	-1.0000	-1.0000
	1.0000	1.0000	1.0000	1.0000
	1	27	27	27
	-2.0000	3.0000	3.0000	3.0000
	1.0000	1.0000	1.0000	1.0000
	27	30	30	30
	5.0000	3.0000	3.0000	3.0000
	1.0000	1.0000	1.0000	1.0000
	30	0	0	0
	5.0000			
	1.0000			
Reaction no.	9	10	11	12
Base component	8	9	12	13

EQUIPMENT SUMMARIES

Frac.conversion	0.9000	0.9000	0.9000	0.9000
	8	9	12	13
	-2.0000	-2.0000	-2.0000	-1.0000
	1.0000	1.0000	1.0000	1.0000
	27	27	27	1
	5.0000	5.0000	1.0000	-3.0000
	1.0000	1.0000	1.0000	1.0000
	30	30	30	27
	5.0000	5.0000	3.0000	3.0000
	1.0000	1.0000	1.0000	1.0000
	0	0	0	30
				3.0000
				1.0000
Reaction no.	13	14	15	16
Base component	14	16	28	29
Frac.conversion	0.9000	0.9000	0.9000	0.9000
	14	16	28	29
	-2.0000	-2.0000	-2.0000	-2.0000
	1.0000	1.0000	1.0000	1.0000
	1	1	1	1
	-6.0000	-2.0000	-2.0000	-6.0000
	1.0000	1.0000	1.0000	1.0000
	27	27	27	27
	5.0000	1.0000	1.0000	1.0000
	1.0000	1.0000	1.0000	1.0000
	30	30	30	30
	5.0000	5.0000	3.0000	9.0000
	1.0000	1.0000	1.0000	1.0000
	0	26	26	26
		3.0000	1.0000	3.0000
		1.0000	1.0000	1.0000
Reaction no.	17	18		
Base component	23	18		
Frac.conversion	0.9000	0.9000		
	23	18		
	-4.0000	-2.0000		
	1.0000	1.0000		
	1	1		
	-362.0000	-214.0000		
	1.0000	1.0000		
	27	27		
	61.0000	19.0000		
	1.0000	1.0000		
	30	30		
	338.0000	181.0000		
	1.0000	1.0000		
	25	26		
	58.0000	107.0000		
	1.0000	1.0000		
	26	0		
	181.0000			
	1.0000			

Reaction Stoichiometrics and Parameters for unit no. 114

EQUIPMENT SUMMARIES

Reaction no.	1
Base component	30
Frac.conversion	0.1630
	30
	-417.0000
	1.0000
	27
	-383.0000
	1.0000
	31
	-184.0000
	1.0000
	20
	8.0000
	1.0000
	1
	454.0000
	1.0000

Equip. No.	118
Name	T-807
No of Reactions	18
Specify thermal mode:	1
C	51.6439
Temperature Units:	2
Pressure Units:	7
Heat of Reaction Units:	4
Molar Flow Units:	1
Reference Temp C	15.0000
Calc Overall Ht of Rxn (kW)	-2334.3513

Reaction Stoichiometrics and Parameters for unit no. 118

Reaction no.	1	2	3	4
Base component	2	5	6	3
Frac.conversion	1.0000	1.0000	1.0000	1.0000
	2	5	6	3
	-1.0000	-1.0000	-1.0000	-1.0000
	1.0000	1.0000	1.0000	1.0000
	26	26	26	26
	-6.0000	-6.0000	-6.0000	-5.0000
	1.0000	1.0000	1.0000	1.0000
	27	27	27	27
	6.0000	6.0000	6.0000	5.0000
	1.0000	1.0000	1.0000	1.0000
	1	1	1	1
	5.0000	5.0000	5.0000	4.0000
	1.0000	1.0000	1.0000	1.0000
Reaction no.	5	6	7	8
Base component	4	7	10	11
Frac.conversion	1.0000	1.0000	1.0000	1.0000
	4	7	10	11
	-1.0000	-1.0000	-1.0000	-1.0000
	1.0000	1.0000	1.0000	1.0000

EQUIPMENT SUMMARIES

	26	26	26	26
	-5.0000	-6.0000	-6.0000	-6.0000
	1.0000	1.0000	1.0000	1.0000
	27	27	27	27
	5.0000	6.0000	6.0000	6.0000
	1.0000	1.0000	1.0000	1.0000
	1	1	1	1
	4.0000	6.0000	6.0000	6.0000
	1.0000	1.0000	1.0000	1.0000
Reaction no.	9	10	11	12
Base component	8	9	12	13
Frac.conversion	1.0000	1.0000	1.0000	1.0000
	8	9	12	13
	-1.0000	-1.0000	-1.0000	-1.0000
	1.0000	1.0000	1.0000	1.0000
	26	26	26	26
	-5.0000	-5.0000	-3.0000	-6.0000
	1.0000	1.0000	1.0000	1.0000
	27	27	27	27
	5.0000	5.0000	2.0000	6.0000
	1.0000	1.0000	1.0000	1.0000
	1	1	1	1
	5.0000	5.0000	3.0000	3.0000
	1.0000	1.0000	1.0000	1.0000
Reaction no.	13	14	15	16
Base component	14	16	18	28
Frac.conversion	1.0000	1.0000	1.0000	1.0000
	14	16	18	28
	-1.0000	-2.0000	-2.0000	-2.0000
	1.0000	1.0000	1.0000	1.0000
	26	26	26	26
	-5.0000	-7.0000	255.0000	-5.0000
	1.0000	1.0000	1.0000	1.0000
	27	27	27	27
	5.0000	6.0000	200.0000	4.0000
	1.0000	1.0000	1.0000	1.0000
	1	1	1	1
	2.0000	8.0000	148.0000	4.0000
	1.0000	1.0000	1.0000	1.0000
Reaction no.	17	18		
Base component	29	23		
Frac.conversion	1.0000	1.0000		
	29	23		
	-2.0000	-1.0000		
	1.0000	1.0000		
	26	26		
	15.0000	102.0000		
	1.0000	1.0000		
	27	27		
	10.0000	100.0000		
	1.0000	1.0000		
	1	1		
	12.0000	35.0000		
	1.0000	1.0000		
	0	31		
		29.0000		

EQUIPMENT SUMMARIES

1.0000

Flash Summary

Equip. No.	9	16	27	37
Name	T-203	(T-206)		(FM-303)
Flash Mode	5	5	2	5
Param 1	108000.0000	108000.0000	37.0000	108000.0000
Param 2			108000.0000	
Heat duty kW			1.0504	
K values:				
Water	1.015	1.006	0.058	0.060
Cellulose	1.000E-010	1.000E-010	1.000E-010	1.000E-010
Xylan	1.000E-020	1.000E-020	1.000E-020	1.000E-020
Arabinan	1.000E-020	1.000E-020	1.000E-020	1.000E-020
Mannan	1.000E-020	1.000E-020	1.000E-020	1.000E-020
Galacatan	1.000E-020	1.000E-020	1.000E-020	1.000E-020
Alpha-D-Glucose	1.000E-010	1.000E-010	1.000E-010	1.000E-010
Xylose	4.667E-003	4.511E-003	1.466E-003	1.441E-003
Arabinose	1.041E-011	9.609E-012	7.755E-018	8.958E-018
Mannose	3.109E-017	2.823E-017	1.000E-020	1.000E-020
Galactose	3.109E-017	2.823E-017	1.000E-020	1.000E-020
Ethanol	11.177	11.125	1.016	0.983
HMF	1032.006	1406.028	193.248	135.132
Furfural	4.291	4.560	0.424	0.422
Calcium Sulfate	1.000E-010	1.000E-010	1.000E-010	1.000E-010
Glycerol	1.288E-004	1.184E-004	2.266E-007	2.440E-007
Lignin	1.000E-010	1.000E-010	1.000E-010	1.000E-010
Soluble Solids	1.000E-020	1.000E-020	1.000E-020	1.000E-020
Ash	1.000E-020	1.000E-020	1.000E-020	1.000E-020
Cell Mass	4.670E-003	4.514E-003	1.467E-003	1.442E-003
Sulfuric Acid	2.422E-013	1.681E-013	1.512E-020	2.254E-020
CalciumHydroxid	1.000E-010	1.000E-010	1.000E-010	1.000E-010
Cellulase	4.670E-003	4.514E-003	1.467E-003	1.442E-003
Air	1.603E+005	1.557E+005	1.052E+005	1.030E+005
Nitrogen	1.603E+005	1.557E+005	1.052E+005	1.030E+005
Oxygen	1.019E+005	98854.180	52696.980	51679.941
Carbon Dioxide	21491.451	20664.934	2322.031	2304.274
Acetaldehyde	47.688	47.432	12.287	10.940
3-Mth-1-Butanol	13.447	15.369	1.061	0.856
Methane	64607.453	62759.059	45664.727	44690.477
Ammonia	61.809	59.663	13.062	12.905

Equip. No.	47	61	76	87
Name				
Flash Mode	2	2	0	0
Param 1	28.0000	28.0000	37.0000	37.0000
Param 2	108000.0000	108000.0000	108000.0000	108000.0000
Heat duty kW	6.0991	6.8555		
K values:				
Water	0.035	0.035	0.058	0.058
Cellulose	1.000E-010	1.000E-010	1.000E-010	1.000E-010

EQUIPMENT SUMMARIES

Xylan	1.000E-020	1.000E-020	1.000E-020	1.000E-020
Arabinan	1.000E-020	1.000E-020	1.000E-020	1.000E-020
Mannan	1.000E-020	1.000E-020	1.000E-020	1.000E-020
Galacatan	1.000E-020	1.000E-020	1.000E-020	1.000E-020
Alpha-D-Glucose	1.000E-010	1.000E-010	1.000E-010	1.000E-010
Xylose	1.227E-003	1.220E-003	1.415E-003	1.349E-003
Arabinose	6.253E-019	6.220E-019	7.482E-018	7.132E-018
Mannose	1.000E-020	1.000E-020	1.000E-020	1.000E-020
Galactose	1.000E-020	1.000E-020	1.000E-020	1.000E-020
Ethanol	0.658	0.658	0.954	0.864
HMF	123.775	124.799	138.625	80.003
Furfural	0.273	0.273	0.410	0.391
Calcium Sulfate	1.000E-010	1.000E-010	1.000E-010	1.000E-010
Glycerol	7.339E-008	7.292E-008	2.235E-007	2.258E-007
Lignin	1.000E-010	1.000E-010	1.000E-010	1.000E-010
Soluble Solids	1.000E-020	1.000E-020	1.000E-020	1.000E-020
Ash	1.000E-020	1.000E-020	1.000E-020	1.000E-020
Cell Mass	1.228E-003	1.221E-003	1.416E-003	1.350E-003
Sulfuric Acid	1.000E-020	1.000E-020	1.731E-020	2.674E-020
CalciumHydroxid	1.000E-010	1.000E-010	1.000E-010	1.000E-010
Cellulase	1.228E-003	1.221E-003	1.416E-003	1.350E-003
Air	90875.906	90393.453	1.015E+005	96703.562
Nitrogen	90875.906	90393.453	1.015E+005	96703.562
Oxygen	45045.992	44806.848	50847.316	48463.477
Carbon Dioxide	63.403	63.067	2240.527	2135.486
Acetaldehyde	9.710	9.671	10.868	8.695
3-Mth-1-Butanol	0.620	0.623	0.855	0.572
Methane	40013.977	39800.812	44061.895	41996.164
Ammonia	10.100	10.047	12.603	12.012

Equip. No.	95	115	119
Name	T-601	(T-804)	
Flash Mode	0	2	2
Param 1	100.0000	35.0000	20.0000
Param 2	126626.0000	101000.0000	102000.0000
Heat duty kW		91.1571	-4535.4229
K values:			
Water	0.265	0.056	0.023
Cellulose	1.000E-010	1.000E-010	1.000E-010
Xylan	1.000E-020	1.000E-020	1.000E-020
Arabinan	1.000E-020	1.000E-020	1.000E-020
Mannan	1.000E-020	1.000E-020	1.000E-020
Galacatan	1.000E-020	1.000E-020	1.000E-020
Alpha-D-Glucose	1.000E-010	1.000E-010	1.000E-010
Xylose	1.173E-003	1.519E-003	1.101E-003
Arabinose	1.839E-012	4.847E-018	6.059E-020
Mannose	4.858E-018	1.000E-020	1.000E-020
Galactose	4.858E-018	1.000E-020	1.000E-020
Ethanol	2.695	0.992	0.460
HMF	248.207	191.857	82.232
Furfural	1.208	0.436	0.198
Calcium Sulfate	1.000E-010	1.000E-010	1.000E-010
Glycerol	2.895E-005	1.861E-007	2.558E-008
Lignin	1.000E-010	1.000E-010	1.000E-010
Soluble Solids	1.000E-020	1.000E-020	1.000E-020

EQUIPMENT SUMMARIES

Ash	1.000E-020	1.000E-020	1.000E-020
Cell Mass	1.174E-003	1.521E-003	1.102E-003
Sulfuric Acid	4.424E-014	1.000E-020	1.000E-020
CalciumHydroxid	1.000E-010	1.000E-010	1.000E-010
Cellulase	1.174E-003	1.521E-003	1.102E-003
Air	41815.133	1.100E+005	82402.977
Nitrogen	41815.133	1.100E+005	82402.977
Oxygen	26280.031	54936.941	40690.090
Carbon Dioxide	5194.697	2335.175	56.245
Acetaldehyde	10.486	12.811	8.359
3-Mth-1-Butanol	2.998	1.166	0.447
Methane	16861.201	47901.332	36670.645
Ammonia	15.382	13.310	8.388

Component Separator Summary

Equip. No.	10	28	30	48
Name	T-203			
Top Temperature Spec	102.0000	37.0000	37.0000	28.0000
Bottom Temperature Spe	102.0000	37.0000	37.0000	28.0000
Split Destination:	1	0	1	0
Pressure Out Pa		108000.0000	108000.0000	
Component No. 2	1.0000		1.0000	
Component No. 3	1.0000		1.0000	
Component No. 4	1.0000		1.0000	
Component No. 5	1.0000		1.0000	
Component No. 6	1.0000		1.0000	
Component No. 7	1.0000		1.0000	
Component No. 8	1.0000		1.0000	
Component No. 9	1.0000		1.0000	
Component No. 10	1.0000		1.0000	
Component No. 11	1.0000		1.0000	
Component No. 15	1.0000		1.0000	
Component No. 16	1.0000		1.0000	
Component No. 17	1.0000		1.0000	
Component No. 18	1.0000		1.0000	
Component No. 19	1.0000		1.0000	
Component No. 20	1.0000		1.0000	
Component No. 21	1.0000		1.0000	
Component No. 22	1.0000		1.0000	
Component No. 23	1.0000		1.0000	
Component No. 24		1.0000		1.0000
Component No. 25		1.0000		1.0000
Component No. 26		1.0000		1.0000
Component No. 27		1.0000		1.0000

Equip. No.	50	62	64	77
Top Temperature Spec	28.0000	28.0000	28.0000	37.0000
Bottom Temperature Spec	28.0000	28.0000	28.0000	37.0000
Pressure Out Pa	108000.0000	108000.0000	108000.0000	
Component No. 1	1.0000	1.0000		
Component No. 12	1.0000	1.0000		
Component No. 13	1.0000	1.0000		

EQUIPMENT SUMMARIES

Component No. 14	1.0000	1.0000		
Component No. 24	1.0000	1.0000	1.0000	1.0000
Component No. 25	1.0000	1.0000	1.0000	1.0000
Component No. 26	1.0000	1.0000	1.0000	1.0000
Component No. 27	1.0000	1.0000	1.0000	1.0000

Equip. No.	79	88	90	96
Name				
Top Temperature Spec	37.0000	37.0000	37.0000	100.0000
Bottom Temperature Spec	37.0000	37.0000	37.0000	100.0000
Split Destination:	0	0	0	1
Pressure Out Pa	108000.0000	108000.0000	108000.0000	126626.0000
Component No. 1	1.0000	1.0000		
Component No. 2				1.0000
Component No. 3				1.0000
Component No. 4				1.0000
Component No. 5				1.0000
Component No. 6				1.0000
Component No. 7				1.0000
Component No. 8				1.0000
Component No. 9				1.0000
Component No. 10				1.0000
Component No. 11				1.0000
Component No. 12	1.0000	1.0000		
Component No. 13	1.0000	1.0000		
Component No. 14	1.0000	1.0000		
Component No. 15				1.0000
Component No. 17				1.0000
Component No. 18				1.0000
Component No. 19				1.0000
Component No. 20				1.0000
Component No. 21				1.0000
Component No. 22				1.0000
Component No. 23				1.0000
Component No. 24	1.0000	1.0000	1.0000	
Component No. 25	0.5000	1.0000	1.0000	
Component No. 26	1.0000	1.0000	1.0000	
Component No. 27	1.0000	1.0000		
Component No. 28		1.0000		
Component No. 29		1.0000		

Equip. No.	99	102	120
Name	GC-609	GV-808	
Top Temperature Specification	100.0000	100.0000	20.0000
Bottom Temperature Specificat	100.0000	100.0000	20.0000
Pressure Out Pa		108000.0000	
Component No. 1		0.9678	0.9900
Component No. 2		0.0500	
Component No. 3		0.0500	
Component No. 4		0.0500	
Component No. 5		0.0500	
Component No. 6		0.0500	
Component No. 7		0.9660	
Component No. 8		0.9660	
Component No. 9		0.9660	
Component No. 10		0.9660	

EQUIPMENT SUMMARIES

Component No. 11		0.9660	
Component No. 12		0.9660	
Component No. 13	1.0000	0.9660	
Component No. 14		0.9660	
Component No. 15		0.0500	0.0500
Component No. 16		0.9660	
Component No. 17		0.0500	0.0500
Component No. 18		0.0500	
Component No. 19		0.0500	0.0500
Component No. 20		0.0500	0.0500
Component No. 21		0.0500	
Component No. 22		0.0500	
Component No. 23		1.0000	0.0500
Component No. 24	1.0000	1.0000	1.0000
Component No. 25	1.0000	1.0000	1.0000
Component No. 26	1.0000	1.0000	1.0000
Component No. 27	1.0000	1.0000	1.0000
Component No. 28		0.9660	
Component No. 29	1.0000	0.9660	
Component No. 30			1.0000
Component No. 31			1.0000

Heat Exchanger Summary

Equip. No.	18	20	26	36
Name	TT-220	TT-301A	COILS	COILS
Pressure drop 1 Pa	68900.0000	68900.0000		68900.0000
T Out Str 1 C	37.0000	37.0000	37.0000	37.0000
T Out Str 2 C	44.0000	44.0000	13.0000	32.0000
U W/m2-K	1278.0000	1278.0000	1278.0000	1278.0000
Shells in Series	1	1	1	1
No. of SS Passes	1	1	1	1
No. of TS Passes	1	1	1	1
Calc Ht Duty kW	-31222.4004	-1821.8668	-1190.8571	-9892.2354

Equip. No.	40	41	46	52
Name	TT-401A	TT-401B	COILS	TT-402A
Pressure drop 1 Pa	68900.0000	68900.0000		68900.0000
T Out Str 1 C	35.0000	28.0000	28.0000	35.0000
T Out Str 2 C	44.0000	13.0000	13.0000	44.0000
U W/m2-K	1278.0000	1278.0000	1278.0000	1278.0000
Shells in Series	1	1	1	1
No. of SS Passes	1	1	1	1
No. of TS Passes	1	1	1	1
Calc Ht Duty kW	-3.4576	-0.3686	-21.2656	-1127.4597

Equip. No.	53	60	75	86
Name	TT-402B	COILS	COILS	COILS
Pressure drop 1 Pa	68900.0000			
T Out Str 1 C	27.0000	28.0000	37.0000	37.0000
T Out Str 2 C	13.0000	13.0000	32.0000	32.0000
U W/m2-K	1278.0000	1278.0000	1278.0000	1278.0000
Shells in Series	1	1	1	1
No. of SS Passes	1	1	1	1

EQUIPMENT SUMMARIES

No. of TS Passes	1	1	1	1
Calc Ht Duty kW	-137.3453	-3138.3557	-1459.4891	-6071.8892

Equip. No.	93	94	97	112
Name	TT-615	TT-613	(REBOILER)	TT-802
Pressure drop 1 Pa	68900.0000	68900.0000		68900.0000
Pressure drop 2 Pa	13799.9990			
T Out Str 1 C		100.0000	106.0000	35.0000
T Out Str 2 C		148.0000	148.0000	44.0000
Subcooling Str 2 C	1.0000			
U W/m2-K	2272.0000	3976.0002	3976.0002	1278.0000
Shells in Series	1	1	1	1
No. of SS Passes	1	1	1	1
No. of TS Passes	1	1	1	1
No. of Zones	1	0	0	0
Calc Ht Duty kW	11441.8545	21214.6230	29.1290	-9258.0371
LMTD C	46.3528			
LMTD Corr F	1.0000			
Calc Area m2	108.6458			

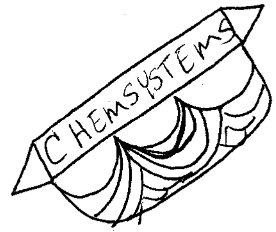
Divider Summary

Equip. No.	19	21	39	67
Name				
Output stream #1	0.9787	0.0414	0.0031	0.2000
Output stream #2	0.0213	0.9586	0.9969	0.8000

Equip. No.	68	108
Name		
Split based on	0	3
Flow rate units	0	4
Output stream #1	0.2000	14000.0000
Output stream #2	0.8000	274400.0000
Output stream #3		25000.0000
Output stream #4		46.0000
Output stream #5		15000.0000

Compressor Summary

Equip. No.	128
Name	PB-810
Type of Compressor:	1
Pressure out Pa	108000.0000
Efficiency	0.8500
Actual power kW	9.8720
Cp/Cv	1.3130
Ideal Cp/Cv	1.3084
Theoretical power kW	8.3912



Page: 29

Recycle water

STREAM PROPERTIES

Stream No.	101	102	211	212
Name				
- - Overall - -				
Mass flow kg/h	145125.	190695.	14000.	1155.
Temp C	20.	100.	100.	20.
Pres Pa	446062.	446062.	452000.	108000.
Vapor mass fraction	0.0000	0.0000	0.0000	0.0000
Enth kW	-4.881E+005	-6.617E+005	-5.913E+004	-2557.
Std. sp gr , wtr = 1	1.118	1.091	1.009	1.824
Std. sp gr , air = 1	1.112	0.946	0.643	3.386
Average mol wt	32.	27.	19.	98.
Actual dens kg/m3	1131.685	1069.056	968.413	1835.945
Actual vol m3/h	128.	178.	14.	1.

STREAM PROPERTIES

LP steam to preheater

HP steam to preheater

Stream No.	213	214	215	216
Name				
- - Overall - -				
Mass flow kg/h	30416.	20957.	211653.	18256.
Temp C	148.	186.	160.	102.
Pres Pa	446062.	1135500.	1135535.	108000.
Vapor mass fraction	1.000	1.000	0.0000	1.000
Enth kW	-1.119E+005	-7.685E+004	-7.386E+005	-6.560E+004
Std. sp gr , wtr = 1	1.000	1.000	1.143	1.004
Std. sp gr , air = 1	0.622	0.622	0.909	0.638
Average mol wt	18.	18.	26.	18.
Actual dens kg/m3	2.361	5.677	1064.909	0.646
Actual vol m3/h	12882.	3692.	199.	28259.

STREAM PROPERTIES

Stream No.	217	218	221	222
Name				
- - Overall - -				
Mass flow kg/h	274400.	467797.	1751.	467423.
Temp C	100.	100.	20.	102.
Pres Pa	452000.	207000.	207000.	108000.
Vapor mass fraction	0.0000	0.0000	0.0000	0.0000
Enth kW	-1.159E+006	-1.832E+006	-5873.	-1.830E+006
Std. sp gr , wtr = 1	1.009	1.066	1.432	1.067
Std. sp gr , air = 1	0.643	0.741	1.001	0.742
Average mol wt	19.	21.	29.	22.
Actual dens kg/m3	968.413	1029.076	1429.765	1029.181
Actual vol m3/h	283.	455.	1.	454.

STREAM PROPERTIES

Stream No.	223	224	301	302
Name				
- - Overall - -				
Mass flow kg/h	457467.	9956.	438527.	18939.
Temp C	37.	37.	37.	37.
Pres Pa	453100.	453100.	453100.	453100.
Vapor mass fraction	0.0000	0.0000	0.0000	0.0000
Enth kW	-1.822E+006	-3.964E+004	-1.746E+006	-7.541E+004
Std. sp gr , wtr = 1	1.067	1.067	1.067	1.067
Std. sp gr , air = 1	0.742	0.742	0.742	0.742
Average mol wt	22.	22.	22.	22.
Actual dens kg/m3	1065.821	1065.821	1065.821	1065.821
Actual vol m3/h	429.	9.	411.	18.

STREAM PROPERTIES

Stream No.	303	304	305	306
Name				
- - Overall - -				
Mass flow kg/h	43144.	481671.	0.	474477.
Temp C	37.	37.	20.	38.
Pres Pa	108000.	108000.	425000.	108000.
Vapor mass fraction	0.0000	0.0000	1.000	0.0000
Enth kW	-1.792E+005	-1.925E+006	-0.046853	-1.903E+006
Std. sp gr , wtr = 1	1.025	1.063	0.619	1.046
Std. sp gr , air = 1	0.678	0.736	0.588	0.723
Average mol wt	20.	21.	17.	21.
Actual dens kg/m3	1034.266	1062.937	3.081	1044.890
Actual vol m3/h	42.	453.	0.	454.

STREAM PROPERTIES

Stream No.	307	308	411	412
Name				
- - Overall - -				
Mass flow kg/h	7194.	474477.	9925.	31.
Temp C	38.	38.	37.	37.
Pres Pa	108000.	453000.	453100.	453100.
Vapor mass fraction	1.000	0.0000	0.0000	0.0000
Enth kW	-1.800E+004	-1.903E+006	-3.952E+004	-122.9
Std. sp gr , wtr = 1	0.831	1.046	1.067	1.067
Std. sp gr , air = 1	1.467	0.723	0.742	0.742
Average mol wt	42.	21.	22.	22.
Actual dens kg/m3	1.786	1044.845	1065.821	1065.821
Actual vol m3/h	4029.	454.	9.	0.

STREAM PROPERTIES

Stream No.	413	414	415	416
Name				
- - Overall - -				
Mass flow kg/h	74.	15000.	450.	111.
Temp C	28.	27.	20.	20.
Pres Pa	108000.	314200.	108000.	452000.
Vapor mass fraction	0.0000	0.0000	0.0000	1.000
Enth kW	-287.6	-6.462E+004	-884.7	-83.89
Std. sp gr , wtr = 1	1.013	1.009	2.523	0.619
Std. sp gr , air = 1	0.718	0.643	6.220	0.588
Average mol wt	21.	19.	180.	17.
Actual dens kg/m3	1117.918	1007.659	2520.983	3.285
Actual vol m3/h	0.	15.	0.	34.

STREAM PROPERTIES

Stream No.	418	419	420	501
Name				
- - Overall - -				
Mass flow kg/h	28307.	29373.	24479.	99791.
Temp C	28.	28.	28.	37.
Pres Pa	790611.	108000.	520000.	108000.
Vapor mass fraction	1.000	1.000	0.0000	0.0000
Enth kW	9.165	-5976.	-1.028E+005	-4.011E+005
Std. sp gr , wtr = 1	0.862	0.856	1.014	1.045
Std. sp gr , air = 1	1.000	1.000	0.665	0.720
Average mol wt	29.	29.	19.	21.
Actual dens kg/m3	9.160	1.250	1038.019	1044.527
Actual vol m3/h	3090.	23496.	24.	96.

STREAM PROPERTIES

Stream No.	502	503	508	510
Name				
- - Overall - -				
Mass flow kg/h	99670.	498835.	15387.	483548.
Temp C	37.	37.	37.	37.
Pres Pa	108000.	108000.	108000.	520000.
Vapor mass fraction	0.0082787	0.0021600	1.000	0.0000
Enth kW	-3.983E+005	-2.003E+006	-3.624E+004	-1.970E+006
Std. sp gr , wtr = 1	1.039	1.044	0.830	1.019
Std. sp gr , air = 1	0.718	0.719	1.428	0.699
Average mol wt	21.	21.	41.	20.
Actual dens kg/m3	123.407	374.922	1.741	1020.054
Actual vol m3/h	808.	1331.	8840.	474.

STREAM PROPERTIES

Stream No.	611	631	632	633
Name				
- - Overall - -				
Mass flow kg/h	433590.	42986.	1.	107936.
Temp C	114.	100.	100.	100.
Pres Pa	492000.	108000.	452000.	452000.
Vapor mass fraction	0.0000	0.0000	0.0000	0.0000
Enth kW	-1.840E+006	-1.340E+005	-4.246	-4.559E+005
Std. sp gr , wtr = 1	1.005	1.329	1.008	1.009
Std. sp gr , air = 1	0.635	1.577	0.640	0.643
Average mol wt	18.	46.	19.	19.
Actual dens kg/m3	952.205	1464.100	966.734	968.413
Actual vol m3/h	455.	29.	0.	111.

STREAM PROPERTIES

Stream No.	634	812	813	821
Name				
- - Overall - -				
Mass flow kg/h	1.	121863.	4458.	2192.
Temp C	15.	35.	41.	20.
Pres Pa	452000.	404000.	108000.	102000.
Vapor mass fraction	0.0000	0.0000	1.000	0.0000
Enth kW	-4.422	-5.311E+005	-6271.	-6224.
Std. sp gr , wtr = 1	1.000	1.001	0.560	1.042
Std. sp gr , air = 1	0.622	0.629	0.880	1.094
Average mol wt	18.	18.	25.	32.
Actual dens kg/m3	998.735	1001.615	1.057	1610.333
Actual vol m3/h	0.	122.	4217.	1.

STREAM PROPERTIES

Stream No.	822	2101	2102	2103
Name				
- - Overall - -				
Mass flow kg/h	120211.	1155.	15155.	190695.
Temp C	20.	20.	98.	100.
Pres Pa	452000.	1073000.	532000.	446062.
Vapor mass fraction	0.0000	0.0000	0.0000	0.0000
Enth kW	-5.293E+005	-2557.	-6.169E+004	-6.617E+005
Std. sp gr , wtr = 1	0.999	1.824	1.044	1.091
Std. sp gr , air = 1	0.625	3.386	0.686	0.946
Average mol wt	18.	98.	20.	27.
Actual dens kg/m3	996.341	1836.122	1003.806	1069.056
Actual vol m3/h	121.	1.	15.	178.

STREAM PROPERTIES

Stream No.	2104	2105	2106	2107
Name				
- - Overall - -				
Mass flow kg/h	211653.	211653.	211653.	18264.
Temp C	176.	160.	160.	102.
Pres Pa	1135535.	1135535.	1135535.	108000.
Vapor mass fraction	0.0000	0.0000	0.0000	1.000
Enth kW	-7.385E+005	-7.386E+005	-7.386E+005	-6.561E+004
Std. sp gr , wtr = 1	1.081	1.143	1.143	1.005
Std. sp gr , air = 1	0.900	0.909	0.909	0.639
Average mol wt	26.	26.	26.	18.
Actual dens kg/m3	1002.022	1064.909	1064.909	0.646
Actual vol m3/h	211.	199.	199.	28280.

STREAM PROPERTIES

Stream No.	2108	2109	2110	2201
Name				
- - Overall - -				
Mass flow kg/h	193389.	8.	467797.	469548.
Temp C	102.	102.	100.	100.
Pres Pa	108000.	108000.	108000.	108000.
Vapor mass fraction	0.0000	0.0000	0.0000	0.0000
Enth kW	-6.730E+005	-19.13	-1.832E+006	-1.838E+006
Std. sp gr , wtr = 1	1.158	1.532	1.066	1.067
Std. sp gr , air = 1	0.946	5.195	0.741	0.742
Average mol wt	27.	150.	21.	21.
Actual dens kg/m3	1128.238	1439.676	1029.100	1030.236
Actual vol m3/h	171.	0.	455.	456.

STREAM PROPERTIES

Stream No.	2202	2203	2204	2205
Name				
- - Overall - -				
Mass flow kg/h	469548.	469548.	2126.	467423.
Temp C	102.	102.	102.	102.
Pres Pa	108000.	108000.	108000.	522000.
Vapor mass fraction	0.0043097	0.0043097	1.000	0.0000
Enth kW	-1.838E+006	-1.838E+006	-7676.	-1.830E+006
Std. sp gr , wtr = 1	1.067	1.067	1.004	1.067
Std. sp gr , air = 1	0.742	0.742	0.635	0.742
Average mol wt	21.	21.	18.	22.
Actual dens kg/m3	130.396	130.396	0.643	1029.062
Actual vol m3/h	3601.	3601.	3305.	454.

STREAM PROPERTIES

Stream No.	2206	3101	3102	3103
Name				
- - Overall - -				
Mass flow kg/h	467423.	25000.	25000.	18485.
Temp C	37.	100.	37.	28.
Pres Pa	453100.	452000.	383100.	790611.
Vapor mass fraction	0.0000	0.0000	0.0000	1.000
Enth kW	-1.861E+006	-1.056E+005	-1.074E+005	5.985
Std. sp gr , wtr = 1	1.067	1.009	1.009	0.862
Std. sp gr , air = 1	0.742	0.643	0.643	1.000
Average mol wt	22.	19.	19.	29.
Actual dens kg/m3	1065.821	968.413	1004.425	9.160
Actual vol m3/h	439.	26.	25.	2018.

STREAM PROPERTIES

Stream No.	3104	3105	3106	3107
Name				
- - Overall - -				
Mass flow kg/h	18.	62520.	62520.	62514.
Temp C	20.	30.	31.	50.
Pres Pa	852000.	108000.	108219.	108219.
Vapor mass fraction	0.0000	0.30438	0.30477	0.32243
Enth kW	-1.504	-1.829E+005	-1.828E+005	-1.818E+005
Std. sp gr , wtr = 1	1.000	0.975	0.975	0.969
Std. sp gr , air = 1	79.846	0.753	0.753	0.750
Average mol wt	2313.	22.	22.	22.
Actual dens kg/m3	127676.031	4.003	3.992	3.484
Actual vol m3/h	0.	15617.	15661.	17941.

STREAM PROPERTIES

Stream No.	3108	3109	3110	3111
Name				
- - Overall - -				
Mass flow kg/h	62514.	19369.	43145.	1.
Temp C	37.	37.	37.	37.
Pres Pa	108219.	108000.	108000.	108000.
Vapor mass fraction	0.30981	1.000	0.0000	1.000
Enth kW	-1.830E+005	-3768.	-1.792E+005	-1.619
Std. sp gr , wtr = 1	0.969	0.863	1.025	0.841
Std. sp gr , air = 1	0.750	0.985	0.678	1.225
Average mol wt	22.	29.	20.	35.
Actual dens kg/m3	3.858	1.196	1034.210	1.489
Actual vol m3/h	16205.	16199.	42.	1.

STREAM PROPERTIES

Stream No.	3112	3113	3114	3115
Name				
- - Overall - -				
Mass flow kg/h	19371.	19370.	0.	43144.
Temp C	37.	37.	37.	37.
Pres Pa	108000.	108000.	108000.	108000.
Vapor mass fraction	1.000	1.000	0.0000	0.0000
Enth kW	-3769.	-3769.	-0.020561	-1.792E+005
Std. sp gr , wtr = 1	0.863	0.863	1.000	1.025
Std. sp gr , air = 1	0.985	0.985	79.167	0.678
Average mol wt	29.	29.	2293.	20.
Actual dens kg/m3	1.196	1.196	123915.336	1034.260
Actual vol m3/h	16199.	16199.	0.	42.

STREAM PROPERTIES

Stream No.	3116	3117	3118	3119
Name				
- - Overall - -				
Mass flow kg/h	62520.	481671.	481671.	481671.
Temp C	31.	37.	37.	57.
Pres Pa	108219.	108084.	108084.	108084.
Vapor mass fraction	0.30477	0.0000	0.0000	0.016428
Enth kW	-1.828E+005	-1.925E+006	-1.925E+006	-1.911E+006
Std. sp gr , wtr = 1	0.975	1.063	1.063	1.042
Std. sp gr , air = 1	0.753	0.736	0.736	0.728
Average mol wt	22.	21.	21.	21.
Actual dens kg/m3	3.992	1062.866	1062.866	88.131
Actual vol m3/h	15661.	453.	453.	5465.

STREAM PROPERTIES

Stream No.	3120	3121	3122	3123
Name				
- - Overall - -				
Mass flow kg/h	481671.	78.	62514.	481671.
Temp C	37.	20.	50.	57.
Pres Pa	39184.	425000.	108219.	108084.
Vapor mass fraction	0.016583	1.000	0.32243	0.016428
Enth kW	-1.921E+006	-59.02	-1.818E+005	-1.911E+006
Std. sp gr , wtr = 1	1.042	0.619	0.969	1.042
Std. sp gr , air = 1	0.728	0.588	0.750	0.728
Average mol wt	21.	17.	22.	21.
Actual dens kg/m3	35.500	3.081	3.484	88.131
Actual vol m3/h	13568.	25.	17941.	5465.

STREAM PROPERTIES

Stream No.	4101	4102	4103	4104
Name				
- - Overall - -				
Mass flow kg/h	46.	46.	46.	515.
Temp C	100.	35.	28.	28.
Pres Pa	452000.	383100.	314200.	790611.
Vapor mass fraction	0.0000	0.0000	0.0000	1.000
Enth kW	-194.3	-197.7	-198.1	0.16687
Std. sp gr , wtr = 1	1.009	1.009	1.009	0.862
Std. sp gr , air = 1	0.643	0.643	0.643	1.000
Average mol wt	19.	19.	19.	29.
Actual dens kg/m3	968.413	1005.139	1007.374	9.160
Actual vol m3/h	0.	0.	0.	56.

STREAM PROPERTIES

Stream No.	4105	4106	4107	4108
Name				
- - Overall - -				
Mass flow kg/h	10.	603.	603.	603.
Temp C	20.	23.	45.	45.
Pres Pa	852000.	432000.	433798.	433798.
Vapor mass fraction	0.0000	0.85939	0.86819	0.86819
Enth kW	-19.66	-341.4	-332.8	-332.8
Std. sp gr , wtr = 1	2.523	0.890	0.890	0.890
Std. sp gr , air = 1	6.220	0.954	0.954	0.954
Average mol wt	180.	28.	28.	28.
Actual dens kg/m3	2520.983	5.901	5.420	5.420
Actual vol m3/h	0.	102.	111.	111.

STREAM PROPERTIES

Stream No.	4109	4110	4111	4112
Name				
- - Overall - -				
Mass flow kg/h	603.	603.	530.	74.
Temp C	67.	28.	28.	28.
Pres Pa	433798.	433798.	108000.	108000.
Vapor mass fraction	0.89433	0.86278	1.000	0.0000
Enth kW	-334.0	-355.2	-61.51	-287.6
Std. sp gr , wtr = 1	0.878	0.878	0.862	1.014
Std. sp gr , air = 1	0.946	0.946	0.990	0.718
Average mol wt	27.	27.	29.	21.
Actual dens kg/m3	4.871	5.821	1.238	1118.084
Actual vol m3/h	124.	104.	428.	0.

STREAM PROPERTIES

Stream No.	4113	4114	4115	4116
Name				
- - Overall - -				
Mass flow kg/h	530.	0.	74.	530.
Temp C	28.	28.	28.	28.
Pres Pa	108000.	108000.	108000.	108000.
Vapor mass fraction	1.000	1.000	0.0000	1.000
Enth kW	-61.51	-0.055469	-287.6	-61.57
Std. sp gr , wtr = 1	0.862	0.828	1.014	0.862
Std. sp gr , air = 1	0.990	1.484	0.717	0.990
Average mol wt	29.	43.	21.	29.
Actual dens kg/m3	1.238	1.863	1118.363	1.238
Actual vol m3/h	428.	0.	0.	428.

STREAM PROPERTIES

Stream No.	4117	4118	4119	4120
Name				
- - Overall - -				
Mass flow kg/h	0.	15000.	15000.	53867.
Temp C	28.	100.	35.	21.
Pres Pa	108000.	452000.	383100.	108000.
Vapor mass fraction	0.72298	0.0000	0.0000	0.53551
Enth kW	-0.059120	-6.336E+004	-6.448E+004	-1.054E+005
Std. sp gr , wtr = 1	0.721	1.009	1.009	0.938
Std. sp gr , air = 1	0.932	0.643	0.643	0.824
Average mol wt	27.	19.	19.	24.
Actual dens kg/m3	1.178	968.413	1005.139	2.358
Actual vol m3/h	0.	15.	15.	22849.

STREAM PROPERTIES

Stream No.	4121	4122	4123	4124
Name				
- - Overall - -				
Mass flow kg/h	53867.	53867.	53864.	53852.
Temp C	30.	30.	38.	59.
Pres Pa	109652.	109652.	109652.	109652.
Vapor mass fraction	0.54140	0.54140	0.55004	0.60365
Enth kW	-1.049E+005	-1.049E+005	-1.050E+005	-1.056E+005
Std. sp gr , wtr = 1	0.938	0.938	0.933	0.921
Std. sp gr , air = 1	0.824	0.824	0.822	0.814
Average mol wt	24.	24.	24.	24.
Actual dens kg/m3	2.283	2.283	2.186	1.803
Actual vol m3/h	23595.	23595.	24644.	29868.

STREAM PROPERTIES

Stream No.	4125	4126	4127	4128
Name				
- - Overall - -				
Mass flow kg/h	53852.	53852.	29345.	24507.
Temp C	59.	28.	28.	28.
Pres Pa	109652.	109652.	108000.	108000.
Vapor mass fraction	0.60365	0.54472	1.000	0.0000
Enth kW	-1.056E+005	-1.088E+005	-5906.	-1.029E+005
Std. sp gr , wtr = 1	0.921	0.921	0.856	1.013
Std. sp gr , air = 1	0.814	0.814	1.000	0.666
Average mol wt	24.	24.	29.	19.
Actual dens kg/m3	1.803	2.328	1.250	1037.309
Actual vol m3/h	29868.	23137.	23480.	24.

STREAM PROPERTIES

Stream No.	4129	4130	4131	4132
Name				
- - Overall - -				
Mass flow kg/h	1.	29344.	24508.	29.
Temp C	28.	28.	28.	28.
Pres Pa	108000.	108000.	108000.	108000.
Vapor mass fraction	0.11522	1.000	0.0000	1.000
Enth kW	-0.092217	-5906.	-1.029E+005	-70.11
Std. sp gr , wtr = 1	0.941	0.856	1.013	0.827
Std. sp gr , air = 1	5.461	1.000	0.666	1.509
Average mol wt	158.	29.	19.	44.
Actual dens kg/m3	7.381	1.250	1037.332	1.895
Actual vol m3/h	0.	23480.	24.	15.

STREAM PROPERTIES

Stream No.	4133	4134	4135	5101
Name				
- - Overall - -				
Mass flow kg/h	24479.	1.	603.	4896.
Temp C	28.	20.	67.	28.
Pres Pa	108000.	425000.	433798.	520000.
Vapor mass fraction	0.0000	1.000	0.89433	0.0000
Enth kW	-1.028E+005	-0.93938	-334.0	-2.056E+004
Std. sp gr , wtr = 1	1.014	0.619	0.878	1.014
Std. sp gr , air = 1	0.665	0.588	0.946	0.665
Average mol wt	19.	17.	27.	19.
Actual dens kg/m3	1038.058	3.081	4.871	1038.019
Actual vol m3/h	24.	0.	124.	5.

STREAM PROPERTIES

Stream No.	5102	5103	5104	5105
Name				
- - Overall - -				
Mass flow kg/h	19583.	94895.	379582.	0.
Temp C	28.	38.	38.	20.
Pres Pa	520000.	453000.	453000.	852000.
Vapor mass fraction	0.0000	0.0000	0.0000	0.0000
Enth kW	-8.223E+004	-3.806E+005	-1.522E+006	-1.966E-005
Std. sp gr , wtr = 1	1.014	1.046	1.046	2.523
Std. sp gr , air = 1	0.665	0.723	0.723	6.220
Average mol wt	19.	21.	21.	180.
Actual dens kg/m3	1038.019	1044.845	1044.845	2520.983
Actual vol m3/h	19.	91.	363.	0.

STREAM PROPERTIES

Stream No.	5106	5107	5108	5109
Name				
- - Overall - -				
Mass flow kg/h	13913.	0.	113944.	113944.
Temp C	28.	0.	34.	37.
Pres Pa	791000.	0.	108000.	109070.
Vapor mass fraction	1.000	0.0000	0.12924	0.13028
Enth kW	4.501	0.0000	-4.013E+005	-4.009E+005
Std. sp gr , wtr = 1	0.862	0.000	1.017	1.017
Std. sp gr , air = 1	1.000	0.000	0.745	0.745
Average mol wt	29.	0.	22.	22.
Actual dens kg/m3	9.165	0.000	9.233	9.126
Actual vol m3/h	1518.	0.	12341.	12486.

STREAM PROPERTIES

Stream No.	5110	5111	5112	5113
Name				
- - Overall - -				
Mass flow kg/h	113944.	113787.	113787.	113787.
Temp C	37.	48.	48.	37.
Pres Pa	109070.	109070.	109070.	109070.
Vapor mass fraction	0.13028	0.13577	0.13577	0.13094
Enth kW	-4.009E+005	-4.009E+005	-4.009E+005	-4.024E+005
Std. sp gr , wtr = 1	1.017	1.013	1.013	1.013
Std. sp gr , air = 1	0.745	0.744	0.744	0.744
Average mol wt	22.	22.	22.	22.
Actual dens kg/m3	9.126	8.518	8.518	9.263
Actual vol m3/h	12486.	13358.	13358.	12285.

STREAM PROPERTIES

Stream No.	5114	5115	5116	5117
Name				
- - Overall - -				
Mass flow kg/h	14899.	98888.	4.	98883.
Temp C	37.	37.	37.	37.
Pres Pa	109070.	109070.	108000.	108000.
Vapor mass fraction	1.000	0.0000	1.000	0.0000
Enth kW	-4074.	-3.983E+005	-7.831	-3.983E+005
Std. sp gr , wtr = 1	0.858	1.041	0.835	1.042
Std. sp gr , air = 1	0.997	0.716	1.327	0.716
Average mol wt	29.	21.	38.	21.
Actual dens kg/m3	1.222	1048.198	1.614	1048.271
Actual vol m3/h	12190.	94.	3.	94.

STREAM PROPERTIES

Stream No.	5118	5119	5120	5121
Name				
- - Overall - -				
Mass flow kg/h	14117.	14904.	786.	498835.
Temp C	37.	37.	37.	40.
Pres Pa	108000.	108000.	108000.	109115.
Vapor mass fraction	0.99834	1.000	1.000	0.0021884
Enth kW	-4099.	-4081.	2.534	-2.001E+006
Std. sp gr , wtr = 1	0.861	0.858	0.808	1.044
Std. sp gr , air = 1	0.999	0.997	0.967	0.719
Average mol wt	29.	29.	28.	21.
Actual dens kg/m3	1.216	1.210	1.174	371.530
Actual vol m3/h	11613.	12314.	670.	1343.

STREAM PROPERTIES

Stream No.	5122	5123	5124	5125
Name				
- - Overall - -				
Mass flow kg/h	498835.	498934.	498934.	498934.
Temp C	40.	43.	48.	37.
Pres Pa	109115.	109115.	109115.	109115.
Vapor mass fraction	0.0021884	0.0022339	0.032304	0.030838
Enth kW	-2.001E+006	-2.001E+006	-2.000E+006	-2.006E+006
Std. sp gr , wtr = 1	1.044	1.064	1.012	1.012
Std. sp gr , air = 1	0.719	0.725	0.711	0.711
Average mol wt	21.	21.	21.	21.
Actual dens kg/m3	371.530	365.371	48.857	54.096
Actual vol m3/h	1343.	1366.	10212.	9223.

STREAM PROPERTIES

Stream No.	5126	5127	5128	5129
Name				
- - Overall - -				
Mass flow kg/h	15386.	483548.	0.	483548.
Temp C	37.	37.	37.	37.
Pres Pa	109115.	109115.	108000.	108000.
Vapor mass fraction	1.000	0.0000	0.090525	2.258E-006
Enth kW	-3.624E+004	-1.970E+006	-0.14719	-1.970E+006
Std. sp gr , wtr = 1	0.830	1.019	1.103	1.019
Std. sp gr , air = 1	1.428	0.699	4.048	0.699
Average mol wt	41.	20.	117.	20.
Actual dens kg/m3	1.759	1020.111	8.099	1018.771
Actual vol m3/h	8749.	474.	0.	475.

STREAM PROPERTIES

Stream No.	5130	5131	5132	5133
Name				
- - Overall - -				
Mass flow kg/h	1.	15386.	483548.	240.
Temp C	37.	37.	37.	20.
Pres Pa	108000.	108000.	108000.	452000.
Vapor mass fraction	1.000	1.000	0.0000	1.000
Enth kW	0.0019338	-3.624E+004	-1.970E+006	-181.6
Std. sp gr , wtr = 1	0.831	0.830	1.019	0.619
Std. sp gr , air = 1	0.979	1.428	0.699	0.588
Average mol wt	28.	41.	20.	17.
Actual dens kg/m3	1.188	1.741	1020.114	3.285
Actual vol m3/h	0.	8840.	474.	73.

STREAM PROPERTIES

Stream No.	5134	5135	5136	6101
Name				
- - Overall - -				
Mass flow kg/h	100.	498934.	498934.	18256.
Temp C	20.	40.	48.	87.
Pres Pa	452000.	109115.	109115.	94200.
Vapor mass fraction	1.000	0.0021936	0.032304	0.0000
Enth kW	-75.26	-2.001E+006	-2.000E+006	-7.704E+004
Std. sp gr , wtr = 1	0.619	1.043	1.012	1.004
Std. sp gr , air = 1	0.588	0.719	0.711	0.638
Average mol wt	17.	21.	21.	18.
Actual dens kg/m3	3.285	370.531	48.857	969.981
Actual vol m3/h	30.	1347.	10212.	19.

STREAM PROPERTIES

Stream No.	6102	6103	6104	6105
Name				
- - Overall - -				
Mass flow kg/h	483548.	483548.	341.	483206.
Temp C	59.	100.	100.	100.
Pres Pa	451100.	382200.	382200.	382200.
Vapor mass fraction	0.0000	0.00070576	1.000	0.0000
Enth kW	-1.959E+006	-1.937E+006	-867.5	-1.936E+006
Std. sp gr , wtr = 1	1.019	1.019	0.844	1.019
Std. sp gr , air = 1	0.699	0.699	1.294	0.699
Average mol wt	20.	20.	37.	20.
Actual dens kg/m3	1009.233	856.533	4.690	982.590
Actual vol m3/h	479.	565.	73.	492.

STREAM PROPERTIES

Stream No.	6106	6107	6108	6109
Name				
- - Overall - -				
Mass flow kg/h	448694.	34359.	34359.	37039.
Temp C	100.	100.	106.	38.
Pres Pa	126626.	126626.	126626.	108000.
Vapor mass fraction	0.0000	0.0000	0.0000	0.99940
Enth kW	-1.851E+006	-8.511E+004	-8.508E+004	-5.921E+004
Std. sp gr , wtr = 1	0.993	1.544	1.544	0.842
Std. sp gr , air = 1	0.655	5.602	5.602	1.231
Average mol wt	19.	162.	162.	36.
Actual dens kg/m3	946.883	1953.875	1952.826	1.497
Actual vol m3/h	474.	18.	18.	24745.

STREAM PROPERTIES

Stream No.	6110	6208	6301	6302
Name				
- - Overall - -				
Mass flow kg/h	448847.	11419.	467949.	153.
Temp C	100.	115.	102.	100.
Pres Pa	126626.	623000.	108000.	126626.
Vapor mass fraction	0.0028555	0.0000	0.020012	1.000
Enth kW	-1.851E+006	-4.537E+004	-1.925E+006	-353.9
Std. sp gr , wtr = 1	0.993	1.013	1.031	0.826
Std. sp gr , air = 1	0.655	0.670	0.679	1.598
Average mol wt	19.	19.	20.	46.
Actual dens kg/m3	255.881	955.545	30.862	1.897
Actual vol m3/h	1754.	12.	15163.	81.

STREAM PROPERTIES

Stream No.	6303	6304	6305	6306
Name				
- - Overall - -				
Mass flow kg/h	424963.	424963.	436382.	1.
Temp C	100.	100.	100.	82.
Pres Pa	108000.	452000.	452000.	452000.
Vapor mass fraction	0.0000	0.0000	0.0000	0.0000
Enth kW	-1.798E+006	-1.798E+006	-1.843E+006	-4.284
Std. sp gr , wtr = 1	1.009	1.009	1.009	1.006
Std. sp gr , air = 1	0.642	0.642	0.643	0.636
Average mol wt	19.	19.	19.	18.
Actual dens kg/m3	968.784	968.711	968.413	977.390
Actual vol m3/h	439.	439.	451.	0.

STREAM PROPERTIES

Stream No.	6307	6308	8101	8102
Name				
- - Overall - -				
Mass flow kg/h	3.	42986.	18256.	130.
Temp C	66.	100.	87.	20.
Pres Pa	452000.	108000.	194200.	452000.
Vapor mass fraction	0.0000	0.0000	0.0000	1.000
Enth kW	-12.95	-1.340E+005	-7.704E+004	-98.24
Std. sp gr , wtr = 1	1.005	1.329	1.004	0.619
Std. sp gr , air = 1	0.632	1.577	0.638	0.588
Average mol wt	18.	46.	18.	17.
Actual dens kg/m3	985.383	1464.100	969.947	3.285
Actual vol m3/h	0.	29.	19.	40.

STREAM PROPERTIES

Stream No.	8103	8104	8105	8106
Name				
- - Overall - -				
Mass flow kg/h	126322.	126322.	126322.	126321.
Temp C	99.	99.	35.	35.
Pres Pa	108000.	411000.	342100.	342100.
Vapor mass fraction	0.00012872	0.0000	0.0000	0.041526
Enth kW	-5.330E+005	-5.330E+005	-5.423E+005	-5.381E+005
Std. sp gr , wtr = 1	1.007	1.007	1.007	0.968
Std. sp gr , air = 1	0.642	0.642	0.642	0.634
Average mol wt	19.	19.	19.	18.
Actual dens kg/m3	838.925	967.350	1003.344	78.343
Actual vol m3/h	151.	131.	126.	1612.

STREAM PROPERTIES

Stream No.	8107	8108	8109	8110
Name				
- - Overall - -				
Mass flow kg/h	126321.	126321.	121863.	4458.
Temp C	35.	35.	35.	35.
Pres Pa	342100.	342100.	101000.	101000.
Vapor mass fraction	0.033750	0.033750	0.0000	1.000
Enth kW	-5.374E+005	-5.374E+005	-5.311E+005	-6281.
Std. sp gr , wtr = 1	0.974	0.974	1.001	0.560
Std. sp gr , air = 1	0.636	0.636	0.629	0.880
Average mol wt	18.	18.	18.	25.
Actual dens kg/m3	92.934	92.934	1001.644	1.007
Actual vol m3/h	1359.	1359.	122.	4426.

STREAM PROPERTIES

Stream No.	8201	8203	8204	8205
Name				
- - Overall - -				
Mass flow kg/h	750.	122613.	122712.	122712.
Temp C	20.	35.	52.	52.
Pres Pa	404000.	102000.	102000.	102000.
Vapor mass fraction	1.000	0.0064952	0.0086714	0.0086714
Enth kW	-1.184	-5.311E+005	-5.311E+005	-5.311E+005
Std. sp gr , wtr = 1	1.127	1.002	1.000	1.000
Std. sp gr , air = 1	1.105	0.631	0.630	0.630
Average mol wt	32.	18.	18.	18.
Actual dens kg/m3	5.318	161.944	139.917	139.917
Actual vol m3/h	141.	757.	877.	877.

STREAM PROPERTIES

Stream No.	8206	8207	8208
Name			
- - Overall - -			
Mass flow kg/h	309.	122402.	120211.
Temp C	20.	20.	20.
Pres Pa	102000.	102000.	102000.
Vapor mass fraction	1.000	0.0000	0.0000
Enth kW	-157.5	-5.355E+005	-5.293E+005
Std. sp gr , wtr = 1	1.045	0.999	0.999
Std. sp gr , air = 1	1.147	0.629	0.625
Average mol wt	33.	18.	18.
Actual dens kg/m3	1.392	1003.219	996.370
Actual vol m3/h	222.	122.	121.

FLOW SUMMARIES

Stream No.	101	102	211	212
Stream Name				
Temp C	20.0000	100.1885	100.4411	20.0000
Pres Pa	446062.0312	446062.0312	452000.0000	108000.0000
Enth kW	-4.8812E+005	-6.6167E+005	-59134.	-2557.1
Vapor mass fraction	0.00000	0.00000	0.00000	0.00000
Total kg/h	145125.	190695.	14000.	1155.
Component mass fractions				
Water	0.5000	0.6105	0.9609	0.0000
Cellulose	0.2310	0.1758	0.0005	0.0000
Xylan	0.0903	0.0687	0.0000	0.0000
Arabinan	0.0068	0.0051	0.0000	0.0000
Mannan	0.0178	0.0135	0.0000	0.0000
Galacatan	0.0052	0.0040	0.0000	0.0000
Alpha-D-Glucose	0.0000	0.0000	0.0000	0.0000
Xylose	0.0000	0.0004	0.0060	0.0000
Arabinose	0.0000	0.0000	0.0004	0.0000
Mannose	0.0000	0.0000	0.0000	0.0000
Galactose	0.0000	0.0000	0.0000	0.0000
Ethanol	0.0000	0.0000	0.0000	0.0000
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0000	0.0004	0.0053	0.0000
Calcium Sulfate	0.0000	0.0000	0.0002	0.0000
Glycerol	0.0000	0.0016	0.0216	0.0000
Lignin	0.1200	0.0915	0.0021	0.0000
Soluble Solids	0.0280	0.0213	0.0005	0.0000
Ash	0.0010	0.0008	0.0000	0.0000
Cell Mass	0.0000	0.0000	0.0002	0.0000
Sulfuric Acid	0.0000	0.0061	0.0000	1.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0000	0.0002	0.0023	0.0000
Air	0.0000	0.0000	0.0000	0.0000
Nitrogen	0.0000	0.0000	0.0000	0.0000
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0000	0.0000	0.0000	0.0000
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	0.0000	0.0000

FLOW SUMMARIES

Stream No.	213	214	215	216
Stream Name				
Temp C	147.6484	185.5510	159.9985	102.0000
Pres Pa	446062.0312	1135500.0000	1135535.0000	108000.0000
Enth kW	-1.1186E+005	-76851.	-7.3856E+005	-65596.
Vapor mass fraction	1.0000	1.0000	0.00000	1.0000
Total kg/h	30416.	20957.	211653.	18256.
Component mass fractions				
Water	1.0000	1.0000	0.6423	0.9687
Cellulose	0.0000	0.0000	0.1535	0.0000
Xylan	0.0000	0.0000	0.0043	0.0000
Arabinan	0.0000	0.0000	0.0003	0.0000
Mannan	0.0000	0.0000	0.0024	0.0000
Galacatan	0.0000	0.0000	0.0007	0.0000
Alpha-D-Glucose	0.0000	0.0000	0.0053	0.0000
Xylose	0.0000	0.0000	0.0567	0.0000
Arabinose	0.0000	0.0000	0.0042	0.0000
Mannose	0.0000	0.0000	0.0108	0.0000
Galactose	0.0000	0.0000	0.0032	0.0000
Ethanol	0.0000	0.0000	0.0000	0.0000
HMF	0.0000	0.0000	0.0001	0.0016
Furfural	0.0000	0.0000	0.0066	0.0297
Calcium Sulfate	0.0000	0.0000	0.0000	0.0000
Glycerol	0.0000	0.0000	0.0015	0.0000
Lignin	0.0000	0.0000	0.0824	0.0000
Soluble Solids	0.0000	0.0000	0.0192	0.0000
Ash	0.0000	0.0000	0.0007	0.0000
Cell Mass	0.0000	0.0000	0.0000	0.0000
Sulfuric Acid	0.0000	0.0000	0.0055	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0000	0.0000	0.0001	0.0000
Air	0.0000	0.0000	0.0000	0.0000
Nitrogen	0.0000	0.0000	0.0000	0.0000
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0000	0.0000	0.0000	0.0000
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	0.0000	0.0000

FLOW SUMMARIES

Stream No.	217	218	221	222
Stream Name				
Temp C	100.4411	100.4595	20.0000	101.9520
Pres Pa	452000.0000	207000.0000	207000.0000	108000.0000
Enth kW	-1.1590E+006	-1.8319E+006	-5873.4	-1.8301E+006
Vapor mass fraction	0.00000	0.00000	0.00000	0.00000
Total kg/h	274400.	467797.	1751.	467423.
Component mass fractions				
Water	0.9609	0.8162	0.5000	0.8152
Cellulose	0.0005	0.0697	0.0000	0.0698
Xylan	0.0000	0.0020	0.0000	0.0020
Arabinan	0.0000	0.0001	0.0000	0.0001
Mannan	0.0000	0.0011	0.0000	0.0011
Galacatan	0.0000	0.0003	0.0000	0.0003
Alpha-D-Glucose	0.0000	0.0024	0.0000	0.0024
Xylose	0.0060	0.0292	0.0000	0.0292
Arabinose	0.0004	0.0022	0.0000	0.0022
Mannose	0.0000	0.0049	0.0000	0.0049
Galactose	0.0000	0.0014	0.0000	0.0014
Ethanol	0.0000	0.0000	0.0000	0.0000
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0053	0.0048	0.0000	0.0047
Calcium Sulfate	0.0002	0.0001	0.0000	0.0035
Glycerol	0.0216	0.0138	0.0000	0.0138
Lignin	0.0021	0.0385	0.0000	0.0385
Soluble Solids	0.0005	0.0090	0.0000	0.0090
Ash	0.0000	0.0003	0.0000	0.0003
Cell Mass	0.0002	0.0001	0.0000	0.0001
Sulfuric Acid	0.0000	0.0025	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.5000	0.0000
Cellulase	0.0023	0.0013	0.0000	0.0013
Air	0.0000	0.0000	0.0000	0.0000
Nitrogen	0.0000	0.0000	0.0000	0.0000
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0000	0.0000	0.0000	0.0000
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	0.0000	0.0000

FLOW SUMMARIES

Stream No.	223	224	301	302
Stream Name				
Temp C	37.0000	37.0000	37.0000	37.0000
Pres Pa	453100.0312	453100.0312	453100.0312	453100.0312
Enth kW	-1.8216E+006	-39644.	-1.7462E+006	-75414.
Vapor mass fraction	0.00000	0.00000	0.00000	0.00000
Total kg/h	457467.	9956.	438527.	18939.
Component mass fractions				
Water	0.8152	0.8152	0.8152	0.8152
Cellulose	0.0698	0.0698	0.0698	0.0698
Xylan	0.0020	0.0020	0.0020	0.0020
Arabinan	0.0001	0.0001	0.0001	0.0001
Mannan	0.0011	0.0011	0.0011	0.0011
Galacatan	0.0003	0.0003	0.0003	0.0003
Alpha-D-Glucose	0.0024	0.0024	0.0024	0.0024
Xylose	0.0292	0.0292	0.0292	0.0292
Arabinose	0.0022	0.0022	0.0022	0.0022
Mannose	0.0049	0.0049	0.0049	0.0049
Galactose	0.0014	0.0014	0.0014	0.0014
Ethanol	0.0000	0.0000	0.0000	0.0000
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0047	0.0047	0.0047	0.0047
Calcium Sulfate	0.0035	0.0035	0.0035	0.0035
Glycerol	0.0138	0.0138	0.0138	0.0138
Lignin	0.0385	0.0385	0.0385	0.0385
Soluble Solids	0.0090	0.0090	0.0090	0.0090
Ash	0.0003	0.0003	0.0003	0.0003
Cell Mass	0.0001	0.0001	0.0001	0.0001
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0013	0.0013	0.0013	0.0013
Air	0.0000	0.0000	0.0000	0.0000
Nitrogen	0.0000	0.0000	0.0000	0.0000
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0000	0.0000	0.0000	0.0000
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	0.0000	0.0000

FLOW SUMMARIES

Stream No.	303	304	305	306
Stream Name				
Temp C	37.0000	36.9539	20.0000	37.6464
Pres Pa	108000.0000	108000.0000	425000.0000	108000.0000
Enth kW	-1.7923E+005	-1.9254E+006	-0.0468526	-1.9029E+006
Vapor mass fraction	0.00000	0.00000	1.0000	0.00000
Total kg/h	43144.	481671.	0.	474477.
Component mass fractions				
Water	0.9068	0.8234	0.0000	0.8355
Cellulose	0.0309	0.0663	0.0000	0.0673
Xylan	0.0009	0.0019	0.0000	0.0019
Arabinan	0.0001	0.0001	0.0000	0.0001
Mannan	0.0005	0.0011	0.0000	0.0011
Galacatan	0.0001	0.0003	0.0000	0.0003
Alpha-D-Glucose	0.0000	0.0022	0.0000	0.0003
Xylose	0.0000	0.0266	0.0000	0.0039
Arabinose	0.0000	0.0020	0.0000	0.0003
Mannose	0.0000	0.0045	0.0000	0.0007
Galactose	0.0000	0.0013	0.0000	0.0002
Ethanol	0.0000	0.0000	0.0000	0.0161
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0044	0.0047	0.0000	0.0047
Calcium Sulfate	0.0017	0.0034	0.0000	0.0034
Glycerol	0.0190	0.0143	0.0000	0.0145
Lignin	0.0181	0.0367	0.0000	0.0373
Soluble Solids	0.0042	0.0086	0.0000	0.0087
Ash	0.0002	0.0003	0.0000	0.0003
Cell Mass	0.0113	0.0011	0.0000	0.0012
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0019	0.0014	0.0000	0.0014
Air	0.0000	0.0000	0.0000	0.0000
Nitrogen	0.0000	0.0000	0.0000	0.0000
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0000	0.0000	0.0000	0.0008
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	1.0000	0.0000

FLOW SUMMARIES

Stream No.	307	308	411	412
Stream Name				
Temp C	37.6464	37.7658	37.0000	37.0000
Pres Pa	108000.0000	452999.9688	453100.0312	453100.0312
Enth kW	-17999.	-1.9028E+006	-39521.	-122.90
Vapor mass fraction	1.0000	0.00000	0.00000	0.00000
Total kg/h	7194.	474477.	9925.	31.
Component mass fractions				
Water	0.0253	0.8355	0.8152	0.8152
Cellulose	0.0000	0.0673	0.0698	0.0698
Xylan	0.0000	0.0019	0.0020	0.0020
Arabinan	0.0000	0.0001	0.0001	0.0001
Mannan	0.0000	0.0011	0.0011	0.0011
Galacatan	0.0000	0.0003	0.0003	0.0003
Alpha-D-Glucose	0.0000	0.0003	0.0024	0.0024
Xylose	0.0000	0.0039	0.0292	0.0292
Arabinose	0.0000	0.0003	0.0022	0.0022
Mannose	0.0000	0.0007	0.0049	0.0049
Galactose	0.0000	0.0002	0.0014	0.0014
Ethanol	0.0079	0.0161	0.0000	0.0000
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0010	0.0047	0.0047	0.0047
Calcium Sulfate	0.0000	0.0034	0.0035	0.0035
Glycerol	0.0000	0.0145	0.0138	0.0138
Lignin	0.0000	0.0373	0.0385	0.0385
Soluble Solids	0.0000	0.0087	0.0090	0.0090
Ash	0.0000	0.0003	0.0003	0.0003
Cell Mass	0.0000	0.0012	0.0001	0.0001
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0000	0.0014	0.0013	0.0013
Air	0.0000	0.0000	0.0000	0.0000
Nitrogen	0.0000	0.0000	0.0000	0.0000
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.9658	0.0008	0.0000	0.0000
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	0.0000	0.0000

FLOW SUMMARIES

Stream No.	413	414	415	416
Stream Name				
Temp C	28.3525	27.0000	20.0000	20.0000
Pres Pa	108000.0000	314200.0000	108000.0000	452000.0000
Enth kW	-287.61	-64618.	-884.70	-83.886
Vapor mass fraction	0.00000	0.00000	0.00000	1.0000
Total kg/h	74.	15000.	450.	111.
Component mass fractions				
Water	0.8576	0.9604	0.0000	0.0000
Cellulose	0.0000	0.0005	0.0000	0.0000
Xylan	0.0008	0.0000	0.0000	0.0000
Arabinan	0.0001	0.0000	0.0000	0.0000
Mannan	0.0000	0.0000	0.0000	0.0000
Galacatan	0.0000	0.0000	0.0000	0.0000
Alpha-D-Glucose	0.0000	0.0000	1.0000	0.0000
Xylose	0.0000	0.0060	0.0000	0.0000
Arabinose	0.0000	0.0004	0.0000	0.0000
Mannose	0.0000	0.0000	0.0000	0.0000
Galactose	0.0000	0.0000	0.0000	0.0000
Ethanol	0.0000	0.0000	0.0000	0.0000
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0021	0.0051	0.0000	0.0000
Calcium Sulfate	0.0016	0.0002	0.0000	0.0000
Glycerol	0.0197	0.0224	0.0000	0.0000
Lignin	0.0174	0.0021	0.0000	0.0000
Soluble Solids	0.0041	0.0005	0.0000	0.0000
Ash	0.0001	0.0000	0.0000	0.0000
Cell Mass	0.0935	0.0002	0.0000	0.0000
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0019	0.0022	0.0000	0.0000
Air	0.0000	0.0000	0.0000	0.0000
Nitrogen	0.0000	0.0000	0.0000	0.0000
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0000	0.0000	0.0000	0.0000
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0010	0.0000	0.0000	1.0000

FLOW SUMMARIES

Stream No.	418	419	420	501
Stream Name				
Temp C	28.0000	28.0000	28.1319	37.2855
Pres Pa	790611.0000	108000.0000	520000.0000	108000.0000
Enth kW	9.1651	-5976.3	-1.0279E+005	-4.0112E+005
Vapor mass fraction	1.0000	1.0000	0.00000	0.00000
Total kg/h	28307.	29373.	24479.	99791.
Component mass fractions				
Water	0.0000	0.0217	0.9274	0.8400
Cellulose	0.0000	0.0000	0.0000	0.0640
Xylan	0.0000	0.0000	0.0008	0.0019
Arabinan	0.0000	0.0000	0.0001	0.0001
Mannan	0.0000	0.0000	0.0000	0.0010
Galacatan	0.0000	0.0000	0.0000	0.0003
Alpha-D-Glucose	0.0000	0.0000	0.0000	0.0003
Xylose	0.0000	0.0000	0.0000	0.0037
Arabinose	0.0000	0.0000	0.0000	0.0003
Mannose	0.0000	0.0000	0.0000	0.0006
Galactose	0.0000	0.0000	0.0000	0.0002
Ethanol	0.0000	0.0000	0.0000	0.0153
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0000	0.0007	0.0041	0.0047
Calcium Sulfate	0.0000	0.0000	0.0016	0.0033
Glycerol	0.0000	0.0000	0.0194	0.0147
Lignin	0.0000	0.0000	0.0170	0.0363
Soluble Solids	0.0000	0.0000	0.0040	0.0085
Ash	0.0000	0.0000	0.0001	0.0003
Cell Mass	0.0000	0.0000	0.0115	0.0017
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0000	0.0000	0.0141	0.0020
Air	1.0000	0.8125	0.0000	0.0000
Nitrogen	0.0000	0.1156	0.0000	0.0000
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0000	0.0494	0.0000	0.0008
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	0.0000	0.0000

FLOW SUMMARIES

Stream No.	502	503	508	510
Stream Name				
Temp C	36.7592	37.1361	37.0000	37.1443
Pres Pa	108000.0000	108000.0000	108000.0000	520000.0000
Enth kW	-3.9830E+005	-2.0028E+006	-36243.	-1.9699E+006
Vapor mass fraction	0.00914154	0.00240542	1.0000	0.00000
Total kg/h	99670.	498835.	15387.	483548.
Component mass fractions				
Water	0.8397	0.8399	0.0245	0.8592
Cellulose	0.0547	0.0621	0.0000	0.0083
Xylan	0.0019	0.0019	0.0000	0.0004
Arabinan	0.0001	0.0001	0.0000	0.0000
Mannan	0.0009	0.0010	0.0000	0.0002
Galacatan	0.0003	0.0003	0.0000	0.0001
Alpha-D-Glucose	0.0000	0.0002	0.0000	0.0000
Xylose	0.0037	0.0037	0.0000	0.0056
Arabinose	0.0003	0.0003	0.0000	0.0004
Mannose	0.0000	0.0005	0.0000	0.0000
Galactose	0.0000	0.0001	0.0000	0.0000
Ethanol	0.0139	0.0150	0.0187	0.0438
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0045	0.0046	0.0009	0.0048
Calcium Sulfate	0.0033	0.0033	0.0000	0.0034
Glycerol	0.0147	0.0147	0.0000	0.0202
Lignin	0.0363	0.0363	0.0000	0.0374
Soluble Solids	0.0085	0.0085	0.0000	0.0087
Ash	0.0003	0.0003	0.0000	0.0003
Cell Mass	0.0070	0.0027	0.0000	0.0040
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0020	0.0020	0.0000	0.0021
Air	0.0000	0.0000	0.0000	0.0000
Nitrogen	0.0079	0.0016	0.0511	0.0000
Oxygen	0.0000	0.0000	0.0028	0.0000
Carbon Dioxide	0.0000	0.0006	0.9017	0.0009
Acetaldehyde	0.0000	0.0000	0.0003	0.0001
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	0.0000	0.0000

FLOW SUMMARIES

Stream No.	611	631	632	633
Stream Name				
Temp C	113.8000	100.0000	100.1007	100.4411
Pres Pa	491999.9688	108000.0000	452000.0000	452000.0000
Enth kW	-1.8400E+006	-1.3403E+005	-4.2460	-4.5591E+005
Vapor mass fraction	0.00000	0.00000	0.00000	0.00000
Total kg/h	433590.	42986.	1.	107936.
Component mass fractions				
Water	0.9744	0.3160	0.9669	0.9609
Cellulose	0.0000	0.0891	0.0004	0.0005
Xylan	0.0000	0.0041	0.0000	0.0000
Arabinan	0.0000	0.0003	0.0000	0.0000
Mannan	0.0000	0.0022	0.0000	0.0000
Galacatan	0.0000	0.0006	0.0000	0.0000
Alpha-D-Glucose	0.0000	0.0000	0.0000	0.0000
Xylose	0.0000	0.0021	0.0047	0.0060
Arabinose	0.0000	0.0002	0.0004	0.0004
Mannose	0.0000	0.0000	0.0000	0.0000
Galactose	0.0000	0.0000	0.0000	0.0000
Ethanol	0.0000	0.0000	0.0000	0.0000
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0031	0.0011	0.0014	0.0053
Calcium Sulfate	0.0000	0.0368	0.0004	0.0002
Glycerol	0.0225	0.0077	0.0220	0.0216
Lignin	0.0000	0.4000	0.0019	0.0021
Soluble Solids	0.0000	0.0933	0.0004	0.0005
Ash	0.0000	0.0033	0.0000	0.0000
Cell Mass	0.0000	0.0431	0.0003	0.0002
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0001	0.0000	0.0000
Cellulase	0.0000	0.0000	0.0011	0.0023
Air	0.0000	0.0000	0.0000	0.0000
Nitrogen	0.0000	0.0000	0.0000	0.0000
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0000	0.0000	0.0000	0.0000
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	0.0000	0.0000

FLOW SUMMARIES

Stream No.	634	812	813	821
Stream Name				
Temp C	15.0000	35.0852	40.7788	20.0000
Pres Pa	452000.0000	404000.0000	108000.0000	102000.0000
Enth kW	-4.4219	-5.3105E+005	-6270.7	-6224.4
Vapor mass fraction	0.00000	0.00000	1.0000	0.00000
Total kg/h	1.	121863.	4458.	2192.
Component mass fractions				
Water	1.0000	0.9876	0.0395	0.5504
Cellulose	0.0000	0.0000	0.0000	0.0000
Xylan	0.0000	0.0000	0.0000	0.0000
Arabinan	0.0000	0.0000	0.0000	0.0000
Mannan	0.0000	0.0000	0.0000	0.0000
Galacatan	0.0000	0.0000	0.0000	0.0000
Alpha-D-Glucose	0.0000	0.0000	0.0000	0.0000
Xylose	0.0000	0.0005	0.0000	0.0000
Arabinose	0.0000	0.0000	0.0000	0.0000
Mannose	0.0000	0.0000	0.0000	0.0000
Galactose	0.0000	0.0000	0.0000	0.0000
Ethanol	0.0000	0.0000	0.0000	0.0000
HMF	0.0000	0.0000	0.0005	0.0000
Furfural	0.0000	0.0009	0.0003	0.0000
Calcium Sulfate	0.0000	0.0002	0.0000	0.0089
Glycerol	0.0000	0.0019	0.0000	0.0000
Lignin	0.0000	0.0018	0.0000	0.0970
Soluble Solids	0.0000	0.0000	0.0000	0.0000
Ash	0.0000	0.0000	0.0000	0.0008
Cell Mass	0.0000	0.0065	0.0000	0.3428
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0000	0.0002	0.0000	0.0000
Air	0.0000	0.0000	0.0000	0.0000
Nitrogen	0.0000	0.0000	0.0091	0.0000
Oxygen	0.0000	0.0000	0.2888	0.0000
Carbon Dioxide	0.0000	0.0002	0.3426	0.0000
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.3192	0.0000
Ammonia	0.0000	0.0000	0.0000	0.0000

FLOW SUMMARIES

Stream No.	822	2101	2102	2103
Stream Name				
Temp C	20.0970	19.8553	98.2675	100.1885
Pres Pa	452000.0000	1073000.0000	532000.0000	446062.0312
Enth kW	-5.2927E+005	-2556.9	-61686.	-6.6167E+005
Vapor mass fraction	0.00000	0.00000	0.00000	0.00000
Total kg/h	120211.	1155.	15155.	190695.
Component mass fractions				
Water	0.9934	0.0000	0.8872	0.6105
Cellulose	0.0000	0.0000	0.0004	0.1758
Xylan	0.0000	0.0000	0.0000	0.0687
Arabinan	0.0000	0.0000	0.0000	0.0051
Mannan	0.0000	0.0000	0.0000	0.0135
Galacatan	0.0000	0.0000	0.0000	0.0040
Alpha-D-Glucose	0.0000	0.0000	0.0000	0.0000
Xylose	0.0000	0.0000	0.0055	0.0004
Arabinose	0.0000	0.0000	0.0004	0.0000
Mannose	0.0000	0.0000	0.0000	0.0000
Galactose	0.0000	0.0000	0.0000	0.0000
Ethanol	0.0000	0.0000	0.0000	0.0000
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0000	0.0000	0.0047	0.0004
Calcium Sulfate	0.0000	0.0000	0.0002	0.0000
Glycerol	0.0000	0.0000	0.0207	0.0016
Lignin	0.0001	0.0000	0.0019	0.0915
Soluble Solids	0.0000	0.0000	0.0004	0.0213
Ash	0.0000	0.0000	0.0000	0.0008
Cell Mass	0.0003	0.0000	0.0002	0.0000
Sulfuric Acid	0.0000	1.0000	0.0762	0.0061
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0000	0.0000	0.0020	0.0002
Air	0.0000	0.0000	0.0000	0.0000
Nitrogen	0.0000	0.0000	0.0000	0.0000
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0061	0.0000	0.0000	0.0000
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	0.0000	0.0000

FLOW SUMMARIES

Stream No.	2104	2105	2106	2107
Stream Name				
Temp C	175.7972	159.9985	159.9985	102.2499
Pres Pa	1135535.0000	1135535.0000	1135535.0000	108000.0000
Enth kW	-7.3852E+005	-7.3856E+005	-7.3856E+005	-65609.
Vapor mass fraction	0.00000	0.00000	0.00000	1.0000
Total kg/h	211653.	211653.	211653.	18264.
Component mass fractions				
Water	0.6491	0.6423	0.6423	0.9683
Cellulose	0.1584	0.1535	0.1535	0.0000
Xylan	0.0619	0.0043	0.0043	0.0000
Arabinan	0.0046	0.0003	0.0003	0.0000
Mannan	0.0122	0.0024	0.0024	0.0000
Galacatan	0.0036	0.0007	0.0007	0.0000
Alpha-D-Glucose	0.0000	0.0053	0.0053	0.0000
Xylose	0.0004	0.0567	0.0567	0.0005
Arabinose	0.0000	0.0042	0.0042	0.0000
Mannose	0.0000	0.0108	0.0108	0.0000
Galactose	0.0000	0.0032	0.0032	0.0000
Ethanol	0.0000	0.0000	0.0000	0.0000
HMF	0.0000	0.0001	0.0001	0.0016
Furfural	0.0003	0.0066	0.0066	0.0297
Calcium Sulfate	0.0000	0.0000	0.0000	0.0000
Glycerol	0.0015	0.0015	0.0015	0.0000
Lignin	0.0824	0.0824	0.0824	0.0000
Soluble Solids	0.0192	0.0192	0.0192	0.0000
Ash	0.0007	0.0007	0.0007	0.0000
Cell Mass	0.0000	0.0000	0.0000	0.0000
Sulfuric Acid	0.0055	0.0055	0.0055	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0001	0.0001	0.0001	0.0000
Air	0.0000	0.0000	0.0000	0.0000
Nitrogen	0.0000	0.0000	0.0000	0.0000
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0000	0.0000	0.0000	0.0000
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	0.0000	0.0000

FLOW SUMMARIES

Stream No.	2108	2109	2110	2201
Stream Name				
Temp C	102.2499	102.0000	100.4265	100.2263
Pres Pa	108000.0000	108000.0000	108000.0000	108000.0000
Enth kW	-6.7299E+005	-19.125	-1.8319E+006	-1.8378E+006
Vapor mass fraction	0.00000	0.00000	0.00000	0.00000
Total kg/h	193389.	8.	467797.	469548.
Component mass fractions				
Water	0.6115	0.0000	0.8162	0.8150
Cellulose	0.1680	0.0000	0.0697	0.0695
Xylan	0.0047	0.0000	0.0020	0.0020
Arabinan	0.0004	0.0000	0.0001	0.0001
Mannan	0.0027	0.0000	0.0011	0.0011
Galacatan	0.0008	0.0000	0.0003	0.0003
Alpha-D-Glucose	0.0058	0.0000	0.0024	0.0024
Xylose	0.0620	0.9965	0.0292	0.0290
Arabinose	0.0046	0.0000	0.0022	0.0022
Mannose	0.0119	0.0000	0.0049	0.0049
Galactose	0.0035	0.0000	0.0014	0.0014
Ethanol	0.0000	0.0000	0.0000	0.0000
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0044	0.0000	0.0048	0.0048
Calcium Sulfate	0.0000	0.0000	0.0001	0.0001
Glycerol	0.0016	0.0007	0.0138	0.0137
Lignin	0.0902	0.0000	0.0385	0.0384
Soluble Solids	0.0210	0.0000	0.0090	0.0090
Ash	0.0008	0.0000	0.0003	0.0003
Cell Mass	0.0000	0.0003	0.0001	0.0001
Sulfuric Acid	0.0060	0.0000	0.0025	0.0025
CalciumHydroxide	0.0000	0.0000	0.0000	0.0019
Cellulase	0.0002	0.0025	0.0013	0.0013
Air	0.0000	0.0000	0.0000	0.0000
Nitrogen	0.0000	0.0000	0.0000	0.0000
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0000	0.0000	0.0000	0.0000
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	0.0000	0.0000

FLOW SUMMARIES

Stream No.	2202	2203	2204	2205
Stream Name				
Temp C	101.9518	101.9518	101.9520	102.1149
Pres Pa	108000.0000	108000.0000	108000.0000	522000.0000
Enth kW	-1.8378E+006	-1.8378E+006	-7675.6	-1.8300E+006
Vapor mass fraction	0.00486285	0.00486285	1.0000	0.00000
Total kg/h	469548.	469548.	2126.	467423.
Component mass fractions				
Water	0.8159	0.8159	0.9742	0.8152
Cellulose	0.0695	0.0695	0.0000	0.0698
Xylan	0.0020	0.0020	0.0000	0.0020
Arabinan	0.0001	0.0001	0.0000	0.0001
Mannan	0.0011	0.0011	0.0000	0.0011
Galacatan	0.0003	0.0003	0.0000	0.0003
Alpha-D-Glucose	0.0024	0.0024	0.0000	0.0024
Xylose	0.0290	0.0290	0.0002	0.0292
Arabinose	0.0022	0.0022	0.0000	0.0022
Mannose	0.0049	0.0049	0.0000	0.0049
Galactose	0.0014	0.0014	0.0000	0.0014
Ethanol	0.0000	0.0000	0.0002	0.0000
HMF	0.0000	0.0000	0.0001	0.0000
Furfural	0.0048	0.0048	0.0254	0.0047
Calcium Sulfate	0.0035	0.0035	0.0000	0.0035
Glycerol	0.0137	0.0137	0.0000	0.0138
Lignin	0.0384	0.0384	0.0000	0.0385
Soluble Solids	0.0090	0.0090	0.0000	0.0090
Ash	0.0003	0.0003	0.0000	0.0003
Cell Mass	0.0001	0.0001	0.0000	0.0001
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0013	0.0013	0.0000	0.0013
Air	0.0000	0.0000	0.0000	0.0000
Nitrogen	0.0000	0.0000	0.0000	0.0000
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0000	0.0000	0.0000	0.0000
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	0.0000	0.0000

FLOW SUMMARIES

Stream No.	2206	3101	3102	3103
Stream Name				
Temp C	37.0000	100.4411	37.0000	28.0000
Pres Pa	453100.0312	452000.0000	383100.0000	790611.0000
Enth kW	-1.8612E+006	-1.0560E+005	-1.0741E+005	5.9850
Vapor mass fraction	0.00000	0.00000	0.00000	1.0000
Total kg/h	467423.	25000.	25000.	18485.
Component mass fractions				
Water	0.8152	0.9609	0.9604	0.0000
Cellulose	0.0698	0.0005	0.0005	0.0000
Xylan	0.0020	0.0000	0.0000	0.0000
Arabinan	0.0001	0.0000	0.0000	0.0000
Mannan	0.0011	0.0000	0.0000	0.0000
Galacatan	0.0003	0.0000	0.0000	0.0000
Alpha-D-Glucose	0.0024	0.0000	0.0000	0.0000
Xylose	0.0292	0.0060	0.0060	0.0000
Arabinose	0.0022	0.0004	0.0004	0.0000
Mannose	0.0049	0.0000	0.0000	0.0000
Galactose	0.0014	0.0000	0.0000	0.0000
Ethanol	0.0000	0.0000	0.0000	0.0000
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0047	0.0053	0.0051	0.0000
Calcium Sulfate	0.0035	0.0002	0.0002	0.0000
Glycerol	0.0138	0.0216	0.0224	0.0000
Lignin	0.0385	0.0021	0.0021	0.0000
Soluble Solids	0.0090	0.0005	0.0005	0.0000
Ash	0.0003	0.0000	0.0000	0.0000
Cell Mass	0.0001	0.0002	0.0002	0.0000
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0013	0.0023	0.0022	0.0000
Air	0.0000	0.0000	0.0000	1.0000
Nitrogen	0.0000	0.0000	0.0000	0.0000
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0000	0.0000	0.0000	0.0000
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	0.0000	0.0000

FLOW SUMMARIES

Stream No.	3104	3105	3106	3107
Stream Name				
Temp C	20.0000	29.8734	30.7374	49.9741
Pres Pa	852000.0000	108000.0000	108218.5547	108218.5547
Enth kW	-1.5036	-1.8288E+005	-1.8282E+005	-1.8181E+005
Vapor mass fraction	0.00000	0.315649	0.316060	0.334116
Total kg/h	18.	62520.	62520.	62514.
Component mass fractions				
Water	0.0000	0.6310	0.6310	0.6372
Cellulose	0.0000	0.0213	0.0213	0.0213
Xylan	0.0000	0.0006	0.0006	0.0006
Arabinan	0.0000	0.0000	0.0000	0.0000
Mannan	0.0000	0.0003	0.0003	0.0003
Galacatan	0.0000	0.0001	0.0001	0.0001
Alpha-D-Glucose	0.0000	0.0007	0.0007	0.0000
Xylose	0.0000	0.0112	0.0112	0.0000
Arabinose	0.0000	0.0008	0.0008	0.0000
Mannose	0.0000	0.0015	0.0015	0.0000
Galactose	0.0000	0.0004	0.0004	0.0000
Ethanol	0.0000	0.0000	0.0000	0.0000
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0000	0.0034	0.0034	0.0034
Calcium Sulfate	0.0000	0.0012	0.0012	0.0012
Glycerol	0.0000	0.0131	0.0131	0.0131
Lignin	0.0000	0.0125	0.0125	0.0125
Soluble Solids	0.0000	0.0029	0.0029	0.0029
Ash	0.0000	0.0001	0.0001	0.0001
Cell Mass	1.0000	0.0004	0.0004	0.0078
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0000	0.0013	0.0013	0.0013
Air	0.0000	0.2957	0.2957	0.2738
Nitrogen	0.0000	0.0000	0.0000	0.0167
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0000	0.0000	0.0000	0.0076
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0012	0.0012	0.0000

FLOW SUMMARIES

Stream No.	3108	3109	3110	3111
Stream Name				
Temp C	37.0000	37.0000	37.0000	37.0000
Pres Pa	108218.5547	108000.0000	108000.0000	108000.0000
Enth kW	-1.8300E+005	-3767.6	-1.7923E+005	-1.6189
Vapor mass fraction	0.321047	1.0000	0.00000	1.0000
Total kg/h	62514.	19369.	43145.	1.
Component mass fractions				
Water	0.6372	0.0367	0.9067	0.0000
Cellulose	0.0213	0.0000	0.0309	0.0000
Xylan	0.0006	0.0000	0.0009	0.0000
Arabinan	0.0000	0.0000	0.0001	0.0000
Mannan	0.0003	0.0000	0.0005	0.0000
Galacatan	0.0001	0.0000	0.0001	0.0000
Alpha-D-Glucose	0.0000	0.0000	0.0000	0.0000
Xylose	0.0000	0.0000	0.0000	0.0000
Arabinose	0.0000	0.0000	0.0000	0.0000
Mannose	0.0000	0.0000	0.0000	0.0000
Galactose	0.0000	0.0000	0.0000	0.0000
Ethanol	0.0000	0.0000	0.0000	0.0000
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0034	0.0013	0.0044	0.0000
Calcium Sulfate	0.0012	0.0000	0.0017	0.0000
Glycerol	0.0131	0.0000	0.0190	0.0000
Lignin	0.0125	0.0000	0.0181	0.0000
Soluble Solids	0.0029	0.0000	0.0042	0.0000
Ash	0.0001	0.0000	0.0002	0.0000
Cell Mass	0.0078	0.0000	0.0113	0.0000
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0013	0.0000	0.0019	0.0000
Air	0.2738	0.8837	0.0000	0.4331
Nitrogen	0.0167	0.0539	0.0000	0.0264
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0076	0.0244	0.0000	0.5404
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	0.0000	0.0000

FLOW SUMMARIES

Stream No.	3112	3113	3114	3115
Stream Name				
Temp C	37.0000	37.0000	37.0000	37.0000
Pres Pa	108000.0000	108000.0000	108000.0000	108000.0000
Enth kW	-3769.2	-3769.2	-0.0205612	-1.7923E+005
Vapor mass fraction	1.0000	1.0000	0.00000	0.00000
Total kg/h	19371.	19370.	0.	43144.
Component mass fractions				
Water	0.0367	0.0367	0.0000	0.9068
Cellulose	0.0000	0.0000	0.0000	0.0309
Xylan	0.0000	0.0000	0.0000	0.0009
Arabinan	0.0000	0.0000	0.0000	0.0001
Mannan	0.0000	0.0000	0.0000	0.0005
Galacatan	0.0000	0.0000	0.0000	0.0001
Alpha-D-Glucose	0.0000	0.0000	0.0000	0.0000
Xylose	0.0000	0.0000	0.0000	0.0000
Arabinose	0.0000	0.0000	0.0000	0.0000
Mannose	0.0000	0.0000	0.0000	0.0000
Galactose	0.0000	0.0000	0.0000	0.0000
Ethanol	0.0000	0.0000	0.0000	0.0000
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0013	0.0013	0.0000	0.0044
Calcium Sulfate	0.0000	0.0000	0.0000	0.0017
Glycerol	0.0000	0.0000	0.0002	0.0190
Lignin	0.0000	0.0000	0.0000	0.0181
Soluble Solids	0.0000	0.0000	0.0000	0.0042
Ash	0.0000	0.0000	0.0000	0.0002
Cell Mass	0.0000	0.0000	0.8586	0.0113
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0000	0.0000	0.1412	0.0019
Air	0.8837	0.8837	0.0000	0.0000
Nitrogen	0.0539	0.0539	0.0000	0.0000
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0244	0.0244	0.0000	0.0000
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	0.0000	0.0000

FLOW SUMMARIES

Stream No.	3116	3117	3118	3119
Stream Name				
Temp C	30.7374	37.1474	37.1474	57.2015
Pres Pa	108218.5547	108083.9062	108083.9062	108083.9062
Enth kW	-1.8282E+005	-1.9253E+006	-1.9253E+006	-1.9110E+006
Vapor mass fraction	0.316060	0.00000	0.00000	0.0183901
Total kg/h	62520.	481671.	481671.	481671.
Component mass fractions				
Water	0.6310	0.8234	0.8234	0.8234
Cellulose	0.0213	0.0663	0.0663	0.0663
Xylan	0.0006	0.0019	0.0019	0.0019
Arabinan	0.0000	0.0001	0.0001	0.0001
Mannan	0.0003	0.0011	0.0011	0.0011
Galacatan	0.0001	0.0003	0.0003	0.0003
Alpha-D-Glucose	0.0007	0.0022	0.0022	0.0003
Xylose	0.0112	0.0266	0.0266	0.0039
Arabinose	0.0008	0.0020	0.0020	0.0003
Mannose	0.0015	0.0045	0.0045	0.0006
Galactose	0.0004	0.0013	0.0013	0.0002
Ethanol	0.0000	0.0000	0.0000	0.0160
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0034	0.0047	0.0047	0.0047
Calcium Sulfate	0.0012	0.0034	0.0034	0.0034
Glycerol	0.0131	0.0143	0.0143	0.0143
Lignin	0.0125	0.0367	0.0367	0.0367
Soluble Solids	0.0029	0.0086	0.0086	0.0086
Ash	0.0001	0.0003	0.0003	0.0003
Cell Mass	0.0004	0.0011	0.0011	0.0011
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0013	0.0014	0.0014	0.0014
Air	0.2957	0.0000	0.0000	0.0000
Nitrogen	0.0000	0.0000	0.0000	0.0000
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0000	0.0000	0.0000	0.0152
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0012	0.0000	0.0000	0.0000

FLOW SUMMARIES

Stream No.	3120	3121	3122	3123
Stream Name				
Temp C	37.0000	20.0000	49.9741	57.2015
Pres Pa	39183.9062	425000.0000	108218.5547	108083.9062
Enth kW	-1.9209E+006	-59.019	-1.8181E+005	-1.9110E+006
Vapor mass fraction	0.0185639	1.0000	0.334116	0.0183901
Total kg/h	481671.	78.	62514.	481671.
Component mass fractions				
Water	0.8234	0.0000	0.6372	0.8234
Cellulose	0.0663	0.0000	0.0213	0.0663
Xylan	0.0019	0.0000	0.0006	0.0019
Arabinan	0.0001	0.0000	0.0000	0.0001
Mannan	0.0011	0.0000	0.0003	0.0011
Galacatan	0.0003	0.0000	0.0001	0.0003
Alpha-D-Glucose	0.0003	0.0000	0.0000	0.0003
Xylose	0.0039	0.0000	0.0000	0.0039
Arabinose	0.0003	0.0000	0.0000	0.0003
Mannose	0.0006	0.0000	0.0000	0.0006
Galactose	0.0002	0.0000	0.0000	0.0002
Ethanol	0.0160	0.0000	0.0000	0.0160
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0047	0.0000	0.0034	0.0047
Calcium Sulfate	0.0034	0.0000	0.0012	0.0034
Glycerol	0.0143	0.0000	0.0131	0.0143
Lignin	0.0367	0.0000	0.0125	0.0367
Soluble Solids	0.0086	0.0000	0.0029	0.0086
Ash	0.0003	0.0000	0.0001	0.0003
Cell Mass	0.0011	0.0000	0.0078	0.0011
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0014	0.0000	0.0013	0.0014
Air	0.0000	0.0000	0.2738	0.0000
Nitrogen	0.0000	0.0000	0.0167	0.0000
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0152	0.0000	0.0076	0.0152
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	1.0000	0.0000	0.0000

FLOW SUMMARIES

Stream No.	4101	4102	4103	4104
Stream Name				
Temp C	100.4411	35.0000	28.0000	28.0000
Pres Pa	452000.0000	383100.0000	314200.0000	790611.0000
Enth kW	-194.30	-197.74	-198.11	0.166867
Vapor mass fraction	0.00000	0.00000	0.00000	1.0000
Total kg/h	46.	46.	46.	515.
Component mass fractions				
Water	0.9609	0.9604	0.9604	0.0000
Cellulose	0.0005	0.0005	0.0005	0.0000
Xylan	0.0000	0.0000	0.0000	0.0000
Arabinan	0.0000	0.0000	0.0000	0.0000
Mannan	0.0000	0.0000	0.0000	0.0000
Galacatan	0.0000	0.0000	0.0000	0.0000
Alpha-D-Glucose	0.0000	0.0000	0.0000	0.0000
Xylose	0.0060	0.0060	0.0060	0.0000
Arabinose	0.0004	0.0004	0.0004	0.0000
Mannose	0.0000	0.0000	0.0000	0.0000
Galactose	0.0000	0.0000	0.0000	0.0000
Ethanol	0.0000	0.0000	0.0000	0.0000
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0053	0.0051	0.0051	0.0000
Calcium Sulfate	0.0002	0.0002	0.0002	0.0000
Glycerol	0.0216	0.0224	0.0224	0.0000
Lignin	0.0021	0.0021	0.0021	0.0000
Soluble Solids	0.0005	0.0005	0.0005	0.0000
Ash	0.0000	0.0000	0.0000	0.0000
Cell Mass	0.0002	0.0002	0.0002	0.0000
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0023	0.0022	0.0022	0.0000
Air	0.0000	0.0000	0.0000	1.0000
Nitrogen	0.0000	0.0000	0.0000	0.0000
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0000	0.0000	0.0000	0.0000
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	0.0000	0.0000

FLOW SUMMARIES

Stream No.	4105	4106	4107	4108
Stream Name				
Temp C	20.0000	22.6183	44.9379	44.9379
Pres Pa	852000.0000	432000.0000	433798.3125	433798.3125
Enth kW	-19.660	-341.44	-332.81	-332.81
Vapor mass fraction	0.00000	0.879279	0.888288	0.888288
Total kg/h	10.	603.	603.	603.
Component mass fractions				
Water	0.0000	0.1149	0.1149	0.1149
Cellulose	0.0000	0.0036	0.0036	0.0036
Xylan	0.0000	0.0001	0.0001	0.0001
Arabinan	0.0000	0.0000	0.0000	0.0000
Mannan	0.0000	0.0001	0.0001	0.0001
Galacatan	0.0000	0.0000	0.0000	0.0000
Alpha-D-Glucose	1.0000	0.0167	0.0167	0.0167
Xylose	0.0000	0.0019	0.0019	0.0019
Arabinose	0.0000	0.0001	0.0001	0.0001
Mannose	0.0000	0.0003	0.0003	0.0003
Galactose	0.0000	0.0001	0.0001	0.0001
Ethanol	0.0000	0.0000	0.0000	0.0000
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0000	0.0006	0.0006	0.0006
Calcium Sulfate	0.0000	0.0002	0.0002	0.0002
Glycerol	0.0000	0.0024	0.0024	0.0024
Lignin	0.0000	0.0021	0.0021	0.0021
Soluble Solids	0.0000	0.0005	0.0005	0.0005
Ash	0.0000	0.0000	0.0000	0.0000
Cell Mass	0.0000	0.0000	0.0000	0.0000
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0000	0.0002	0.0002	0.0002
Air	0.0000	0.8540	0.8540	0.8540
Nitrogen	0.0000	0.0000	0.0000	0.0000
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0000	0.0000	0.0000	0.0000
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0021	0.0021	0.0021

FLOW SUMMARIES

Stream No.	4109	4110	4111	4112
Stream Name				
Temp C	67.0654	28.0000	28.0000	28.0000
Pres Pa	433798.3125	433798.3125	108000.0000	108000.0000
Enth kW	-333.96	-355.22	-61.512	-287.61
Vapor mass fraction	0.896410	0.864787	1.0000	0.00000
Total kg/h	603.	603.	530.	74.
Component mass fractions				
Water	0.1242	0.1242	0.0220	0.8588
Cellulose	0.0000	0.0000	0.0000	0.0000
Xylan	0.0001	0.0001	0.0000	0.0008
Arabinan	0.0000	0.0000	0.0000	0.0001
Mannan	0.0000	0.0000	0.0000	0.0000
Galacatan	0.0000	0.0000	0.0000	0.0000
Alpha-D-Glucose	0.0000	0.0000	0.0000	0.0000
Xylose	0.0000	0.0000	0.0000	0.0000
Arabinose	0.0000	0.0000	0.0000	0.0000
Mannose	0.0000	0.0000	0.0000	0.0000
Galactose	0.0000	0.0000	0.0000	0.0000
Ethanol	0.0000	0.0000	0.0000	0.0000
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0006	0.0006	0.0004	0.0021
Calcium Sulfate	0.0002	0.0002	0.0000	0.0016
Glycerol	0.0024	0.0024	0.0000	0.0197
Lignin	0.0021	0.0021	0.0000	0.0174
Soluble Solids	0.0005	0.0005	0.0000	0.0041
Ash	0.0000	0.0000	0.0000	0.0001
Cell Mass	0.0114	0.0114	0.0001	0.0930
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0002	0.0002	0.0000	0.0019
Air	0.8185	0.8185	0.9325	0.0000
Nitrogen	0.0272	0.0272	0.0310	0.0000
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0123	0.0123	0.0140	0.0003
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0001	0.0001	0.0001	0.0000

FLOW SUMMARIES

Stream No.	4113	4114	4115	4116
Stream Name				
Temp C	28.0000	28.0000	28.0000	28.0373
Pres Pa	108000.0000	108000.0000	108000.0000	108000.0000
Enth kW	-61.510	-0.0554693	-287.55	-61.567
Vapor mass fraction	1.0000	1.0000	0.00000	1.0000
Total kg/h	530.	0.	74.	530.
Component mass fractions				
Water	0.0220	0.0000	0.8590	0.0220
Cellulose	0.0000	0.0000	0.0000	0.0000
Xylan	0.0000	0.0000	0.0008	0.0000
Arabinan	0.0000	0.0000	0.0001	0.0000
Mannan	0.0000	0.0000	0.0000	0.0000
Galacatan	0.0000	0.0000	0.0000	0.0000
Alpha-D-Glucose	0.0000	0.0000	0.0000	0.0000
Xylose	0.0000	0.0000	0.0000	0.0000
Arabinose	0.0000	0.0000	0.0000	0.0000
Mannose	0.0000	0.0000	0.0000	0.0000
Galactose	0.0000	0.0000	0.0000	0.0000
Ethanol	0.0000	0.0000	0.0000	0.0000
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0004	0.0000	0.0021	0.0004
Calcium Sulfate	0.0000	0.0000	0.0016	0.0000
Glycerol	0.0000	0.0000	0.0197	0.0000
Lignin	0.0000	0.0000	0.0174	0.0000
Soluble Solids	0.0000	0.0000	0.0041	0.0000
Ash	0.0000	0.0000	0.0001	0.0000
Cell Mass	0.0000	0.0000	0.0930	0.0001
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0000	0.0000	0.0019	0.0000
Air	0.9326	0.0445	0.0000	0.9324
Nitrogen	0.0310	0.0015	0.0000	0.0310
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0140	0.9541	0.0000	0.0140
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	0.0000	0.0001

FLOW SUMMARIES

Stream No.	4117	4118	4119	4120
Stream Name				
Temp C	28.0000	100.4411	35.0000	21.3995
Pres Pa	108000.0000	452000.0000	383100.0000	108000.0000
Enth kW	-0.0591201	-63358.	-64481.	-1.0539E+005
Vapor mass fraction	0.722981	0.00000	0.00000	0.552187
Total kg/h	0.	15000.	15000.	53867.
Component mass fractions				
Water	0.0000	0.9609	0.9604	0.4188
Cellulose	0.0000	0.0005	0.0005	0.0130
Xylan	0.0000	0.0000	0.0000	0.0004
Arabinan	0.0000	0.0000	0.0000	0.0000
Mannan	0.0000	0.0000	0.0000	0.0002
Galacatan	0.0000	0.0000	0.0000	0.0001
Alpha-D-Glucose	0.0000	0.0000	0.0000	0.0088
Xylose	0.0000	0.0060	0.0060	0.0070
Arabinose	0.0000	0.0004	0.0004	0.0005
Mannose	0.0000	0.0000	0.0000	0.0009
Galactose	0.0000	0.0000	0.0000	0.0003
Ethanol	0.0000	0.0000	0.0000	0.0000
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0000	0.0053	0.0051	0.0023
Calcium Sulfate	0.0000	0.0002	0.0002	0.0007
Glycerol	0.0000	0.0216	0.0224	0.0088
Lignin	0.0000	0.0021	0.0021	0.0077
Soluble Solids	0.0000	0.0005	0.0005	0.0018
Ash	0.0000	0.0000	0.0000	0.0001
Cell Mass	0.3642	0.0002	0.0002	0.0002
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0075	0.0023	0.0022	0.0009
Air	0.0000	0.0000	0.0000	0.5255
Nitrogen	0.0000	0.0000	0.0000	0.0000
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0000	0.0000	0.0000	0.0000
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.6283	0.0000	0.0000	0.0021

FLOW SUMMARIES

Stream No.	4121	4122	4123	4124
Stream Name				
Temp C	30.4934	30.4934	37.9038	59.1862
Pres Pa	109652.2656	109652.2656	109652.2656	109652.2656
Enth kW	-1.0486E+005	-1.0486E+005	-1.0498E+005	-1.0564E+005
Vapor mass fraction	0.558254	0.558254	0.563052	0.608772
Total kg/h	53867.	53867.	53864.	53852.
Component mass fractions				
Water	0.4188	0.4188	0.4228	0.4334
Cellulose	0.0130	0.0130	0.0088	0.0000
Xylan	0.0004	0.0004	0.0004	0.0004
Arabinan	0.0000	0.0000	0.0000	0.0000
Mannan	0.0002	0.0002	0.0001	0.0000
Galacatan	0.0001	0.0001	0.0000	0.0000
Alpha-D-Glucose	0.0088	0.0088	0.0059	0.0000
Xylose	0.0070	0.0070	0.0048	0.0000
Arabinose	0.0005	0.0005	0.0004	0.0000
Mannose	0.0009	0.0009	0.0006	0.0000
Galactose	0.0003	0.0003	0.0002	0.0000
Ethanol	0.0000	0.0000	0.0000	0.0000
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0023	0.0023	0.0023	0.0023
Calcium Sulfate	0.0007	0.0007	0.0007	0.0007
Glycerol	0.0088	0.0088	0.0088	0.0088
Lignin	0.0077	0.0077	0.0077	0.0077
Soluble Solids	0.0018	0.0018	0.0018	0.0018
Ash	0.0001	0.0001	0.0001	0.0001
Cell Mass	0.0002	0.0002	0.0052	0.0052
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0009	0.0009	0.0009	0.0064
Air	0.5255	0.5255	0.5085	0.4432
Nitrogen	0.0000	0.0000	0.0130	0.0630
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0000	0.0000	0.0058	0.0270
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0021	0.0021	0.0012	0.0000

FLOW SUMMARIES

Stream No.	4125	4126	4127	4128
Stream Name				
Temp C	59.1862	28.0000	28.0000	28.0000
Pres Pa	109652.2656	109652.2656	108000.0000	108000.0000
Enth kW	-1.0564E+005	-1.0878E+005	-5906.2	-1.0286E+005
Vapor mass fraction	0.608772	0.549344	1.0000	0.00000
Total kg/h	53852.	53852.	29345.	24507.
Component mass fractions				
Water	0.4334	0.4334	0.0218	0.9264
Cellulose	0.0000	0.0000	0.0000	0.0000
Xylan	0.0004	0.0004	0.0000	0.0008
Arabinan	0.0000	0.0000	0.0000	0.0001
Mannan	0.0000	0.0000	0.0000	0.0000
Galacatan	0.0000	0.0000	0.0000	0.0000
Alpha-D-Glucose	0.0000	0.0000	0.0000	0.0000
Xylose	0.0000	0.0000	0.0000	0.0000
Arabinose	0.0000	0.0000	0.0000	0.0000
Mannose	0.0000	0.0000	0.0000	0.0000
Galactose	0.0000	0.0000	0.0000	0.0000
Ethanol	0.0000	0.0000	0.0000	0.0000
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0023	0.0023	0.0007	0.0041
Calcium Sulfate	0.0007	0.0007	0.0000	0.0016
Glycerol	0.0088	0.0088	0.0000	0.0193
Lignin	0.0077	0.0077	0.0000	0.0169
Soluble Solids	0.0018	0.0018	0.0000	0.0040
Ash	0.0001	0.0001	0.0000	0.0001
Cell Mass	0.0052	0.0052	0.0000	0.0115
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0064	0.0064	0.0000	0.0141
Air	0.4432	0.4432	0.8133	0.0000
Nitrogen	0.0630	0.0630	0.1157	0.0000
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0270	0.0270	0.0485	0.0012
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	0.0000	0.0000

FLOW SUMMARIES

Stream No.	4129	4130	4131	4132
Stream Name				
Temp C	28.0000	28.0000	28.0000	28.0000
Pres Pa	108000.0000	108000.0000	108000.0000	108000.0000
Enth kW	-0.0922172	-5906.2	-1.0286E+005	-70.107
Vapor mass fraction	0.115219	1.0000	0.00000	1.0000
Total kg/h	1.	29344.	24508.	29.
Component mass fractions				
Water	0.0000	0.0218	0.9263	0.0000
Cellulose	0.0000	0.0000	0.0000	0.0000
Xylan	0.0000	0.0000	0.0008	0.0000
Arabinan	0.0000	0.0000	0.0001	0.0000
Mannan	0.0000	0.0000	0.0000	0.0000
Galacatan	0.0000	0.0000	0.0000	0.0000
Alpha-D-Glucose	0.0000	0.0000	0.0000	0.0000
Xylose	0.0000	0.0000	0.0000	0.0000
Arabinose	0.0000	0.0000	0.0000	0.0000
Mannose	0.0000	0.0000	0.0000	0.0000
Galactose	0.0000	0.0000	0.0000	0.0000
Ethanol	0.0000	0.0000	0.0000	0.0000
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0000	0.0007	0.0041	0.0000
Calcium Sulfate	0.0000	0.0000	0.0016	0.0000
Glycerol	0.0000	0.0000	0.0193	0.0000
Lignin	0.0000	0.0000	0.0169	0.0000
Soluble Solids	0.0000	0.0000	0.0040	0.0000
Ash	0.0000	0.0000	0.0001	0.0000
Cell Mass	0.4037	0.0000	0.0115	0.0000
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.4952	0.0000	0.0141	0.0000
Air	0.0000	0.8133	0.0000	0.0115
Nitrogen	0.0000	0.1157	0.0000	0.0016
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0000	0.0485	0.0012	0.9868
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.1010	0.0000	0.0000	0.0000

FLOW SUMMARIES

Stream No.	4133	4134	4135	5101
Stream Name				
Temp C	28.0000	20.0000	67.0654	28.1319
Pres Pa	108000.0000	425000.0000	433798.3125	520000.0000
Enth kW	-1.0279E+005	-0.939380	-333.96	-20557.
Vapor mass fraction	0.00000	1.0000	0.896410	0.00000
Total kg/h	24479.	1.	603.	4896.
Component mass fractions				
Water	0.9274	0.0000	0.1242	0.9274
Cellulose	0.0000	0.0000	0.0000	0.0000
Xylan	0.0008	0.0000	0.0001	0.0008
Arabinan	0.0001	0.0000	0.0000	0.0001
Mannan	0.0000	0.0000	0.0000	0.0000
Galacatan	0.0000	0.0000	0.0000	0.0000
Alpha-D-Glucose	0.0000	0.0000	0.0000	0.0000
Xylose	0.0000	0.0000	0.0000	0.0000
Arabinose	0.0000	0.0000	0.0000	0.0000
Mannose	0.0000	0.0000	0.0000	0.0000
Galactose	0.0000	0.0000	0.0000	0.0000
Ethanol	0.0000	0.0000	0.0000	0.0000
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0041	0.0000	0.0006	0.0041
Calcium Sulfate	0.0016	0.0000	0.0002	0.0016
Glycerol	0.0194	0.0000	0.0024	0.0194
Lignin	0.0170	0.0000	0.0021	0.0170
Soluble Solids	0.0040	0.0000	0.0005	0.0040
Ash	0.0001	0.0000	0.0000	0.0001
Cell Mass	0.0115	0.0000	0.0114	0.0115
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0141	0.0000	0.0002	0.0141
Air	0.0000	0.0000	0.8185	0.0000
Nitrogen	0.0000	0.0000	0.0272	0.0000
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0000	0.0000	0.0123	0.0000
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	1.0000	0.0001	0.0000

FLOW SUMMARIES

Stream No.	5102	5103	5104	5105
Stream Name				
Temp C	28.1319	37.7658	37.7658	20.0000
Pres Pa	520000.0000	452999.9688	452999.9688	852000.0000
Enth kW	-82230.	-3.8056E+005	-1.5223E+006	-1.9660E-005
Vapor mass fraction	0.00000	0.00000	0.00000	0.00000
Total kg/h	19583.	94895.	379582.	0.
Component mass fractions				
Water	0.9274	0.8355	0.8355	0.0000
Cellulose	0.0000	0.0673	0.0673	0.0000
Xylan	0.0008	0.0019	0.0019	0.0000
Arabinan	0.0001	0.0001	0.0001	0.0000
Mannan	0.0000	0.0011	0.0011	0.0000
Galacatan	0.0000	0.0003	0.0003	0.0000
Alpha-D-Glucose	0.0000	0.0003	0.0003	1.0000
Xylose	0.0000	0.0039	0.0039	0.0000
Arabinose	0.0000	0.0003	0.0003	0.0000
Mannose	0.0000	0.0007	0.0007	0.0000
Galactose	0.0000	0.0002	0.0002	0.0000
Ethanol	0.0000	0.0161	0.0161	0.0000
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0041	0.0047	0.0047	0.0000
Calcium Sulfate	0.0016	0.0034	0.0034	0.0000
Glycerol	0.0194	0.0145	0.0145	0.0000
Lignin	0.0170	0.0373	0.0373	0.0000
Soluble Solids	0.0040	0.0087	0.0087	0.0000
Ash	0.0001	0.0003	0.0003	0.0000
Cell Mass	0.0115	0.0012	0.0012	0.0000
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0141	0.0014	0.0014	0.0000
Air	0.0000	0.0000	0.0000	0.0000
Nitrogen	0.0000	0.0000	0.0000	0.0000
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0000	0.0008	0.0008	0.0000
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	0.0000	0.0000

FLOW SUMMARIES

Stream No.	5106	5107	5108	5109
Stream Name				
Temp C	28.0000	0.0000	33.9331	37.2032
Pres Pa	791000.0000	0.0000	108000.0000	109069.5000
Enth kW	4.5011	0.00000	-4.0130E+005	-4.0088E+005
Vapor mass fraction	1.0000	0.00000	0.142177	0.143324
Total kg/h	13913.	0.	113944.	113944.
Component mass fractions				
Water	0.0000	0.0000	0.7357	0.7357
Cellulose	0.0000	0.0000	0.0561	0.0561
Xylan	0.0000	0.0000	0.0016	0.0016
Arabinan	0.0000	0.0000	0.0001	0.0001
Mannan	0.0000	0.0000	0.0009	0.0009
Galacatan	0.0000	0.0000	0.0003	0.0003
Alpha-D-Glucose	0.0000	0.0000	0.0003	0.0003
Xylose	0.0000	0.0000	0.0033	0.0033
Arabinose	0.0000	0.0000	0.0002	0.0002
Mannose	0.0000	0.0000	0.0005	0.0005
Galactose	0.0000	0.0000	0.0002	0.0002
Ethanol	0.0000	0.0000	0.0134	0.0134
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0000	0.0000	0.0041	0.0041
Calcium Sulfate	0.0000	0.0000	0.0029	0.0029
Glycerol	0.0000	0.0000	0.0129	0.0129
Lignin	0.0000	0.0000	0.0318	0.0318
Soluble Solids	0.0000	0.0000	0.0074	0.0074
Ash	0.0000	0.0000	0.0003	0.0003
Cell Mass	0.0000	0.0000	0.0015	0.0015
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0000	0.0000	0.0018	0.0018
Air	1.0000	0.0000	0.1221	0.1221
Nitrogen	0.0000	0.0000	0.0000	0.0000
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0000	0.0000	0.0007	0.0007
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	0.0021	0.0021

FLOW SUMMARIES

Stream No.	5110	5111	5112	5113
Stream Name				
Temp C	37.2032	47.6848	47.6848	37.0000
Pres Pa	109069.5000	109069.5000	109069.5000	109069.5000
Enth kW	-4.0088E+005	-4.0093E+005	-4.0093E+005	-4.0239E+005
Vapor mass fraction	0.143324	0.148002	0.148002	0.142743
Total kg/h	113944.	113787.	113787.	113787.
Component mass fractions				
Water	0.7357	0.7402	0.7402	0.7402
Cellulose	0.0561	0.0479	0.0479	0.0479
Xylan	0.0016	0.0016	0.0016	0.0016
Arabinan	0.0001	0.0001	0.0001	0.0001
Mannan	0.0009	0.0008	0.0008	0.0008
Galacatan	0.0003	0.0002	0.0002	0.0002
Alpha-D-Glucose	0.0003	0.0000	0.0000	0.0000
Xylose	0.0033	0.0033	0.0033	0.0033
Arabinose	0.0002	0.0002	0.0002	0.0002
Mannose	0.0005	0.0000	0.0000	0.0000
Galactose	0.0002	0.0000	0.0000	0.0000
Ethanol	0.0134	0.0134	0.0134	0.0134
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0041	0.0041	0.0041	0.0041
Calcium Sulfate	0.0029	0.0029	0.0029	0.0029
Glycerol	0.0129	0.0129	0.0129	0.0129
Lignin	0.0318	0.0318	0.0318	0.0318
Soluble Solids	0.0074	0.0074	0.0074	0.0074
Ash	0.0003	0.0003	0.0003	0.0003
Cell Mass	0.0015	0.0061	0.0061	0.0061
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0018	0.0018	0.0018	0.0018
Air	0.1221	0.1042	0.1042	0.1042
Nitrogen	0.0000	0.0138	0.0138	0.0138
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0007	0.0069	0.0069	0.0069
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0021	0.0000	0.0000	0.0000

FLOW SUMMARIES

Stream No.	5114	5115	5116	5117
Stream Name				
Temp C	37.0000	37.0000	37.0000	37.0000
Pres Pa	109069.5000	109069.5000	108000.0000	108000.0000
Enth kW	-4073.6	-3.9831E+005	-7.8309	-3.9831E+005
Vapor mass fraction	1.0000	0.00000	1.0000	0.00000
Total kg/h	14899.	98888.	4.	98883.
Component mass fractions				
Water	0.0356	0.8463	0.0000	0.8464
Cellulose	0.0000	0.0552	0.0000	0.0552
Xylan	0.0000	0.0019	0.0000	0.0019
Arabinan	0.0000	0.0001	0.0000	0.0001
Mannan	0.0000	0.0009	0.0000	0.0009
Galacatan	0.0000	0.0003	0.0000	0.0003
Alpha-D-Glucose	0.0000	0.0000	0.0000	0.0000
Xylose	0.0000	0.0038	0.0000	0.0038
Arabinose	0.0000	0.0003	0.0000	0.0003
Mannose	0.0000	0.0000	0.0000	0.0000
Galactose	0.0000	0.0000	0.0000	0.0000
Ethanol	0.0097	0.0140	0.0000	0.0140
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0014	0.0045	0.0000	0.0045
Calcium Sulfate	0.0000	0.0034	0.0000	0.0034
Glycerol	0.0000	0.0149	0.0000	0.0149
Lignin	0.0000	0.0366	0.0000	0.0366
Soluble Solids	0.0000	0.0085	0.0000	0.0085
Ash	0.0000	0.0003	0.0000	0.0003
Cell Mass	0.0000	0.0071	0.0000	0.0071
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0000	0.0021	0.0000	0.0021
Air	0.7956	0.0000	0.2440	0.0000
Nitrogen	0.1055	0.0000	0.0324	0.0000
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0521	0.0000	0.7237	0.0000
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	0.0000	0.0000

FLOW SUMMARIES

Stream No.	5118	5119	5120	5121
Stream Name				
Temp C	37.0000	37.0000	37.0000	39.9983
Pres Pa	108000.0000	108000.0000	108000.0000	109115.3359
Enth kW	-4099.5	-4081.5	2.5343	-2.0013E+006
Vapor mass fraction	0.998343	1.0000	1.0000	0.00243698
Total kg/h	14117.	14904.	786.	498835.
Component mass fractions				
Water	0.0376	0.0356	0.0000	0.8399
Cellulose	0.0000	0.0000	0.0000	0.0621
Xylan	0.0000	0.0000	0.0000	0.0019
Arabinan	0.0000	0.0000	0.0000	0.0001
Mannan	0.0000	0.0000	0.0000	0.0010
Galacatan	0.0000	0.0000	0.0000	0.0003
Alpha-D-Glucose	0.0000	0.0000	0.0000	0.0002
Xylose	0.0000	0.0000	0.0001	0.0037
Arabinose	0.0000	0.0000	0.0000	0.0003
Mannose	0.0000	0.0000	0.0000	0.0005
Galactose	0.0000	0.0000	0.0000	0.0001
Ethanol	0.0103	0.0097	0.0000	0.0150
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0014	0.0014	0.0000	0.0046
Calcium Sulfate	0.0000	0.0000	0.0000	0.0033
Glycerol	0.0000	0.0000	0.0000	0.0147
Lignin	0.0000	0.0000	0.0000	0.0363
Soluble Solids	0.0000	0.0000	0.0000	0.0085
Ash	0.0000	0.0000	0.0000	0.0003
Cell Mass	0.0000	0.0000	0.0001	0.0027
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0000	0.0000	0.0000	0.0020
Air	0.8398	0.7955	0.0000	0.0000
Nitrogen	0.0557	0.1055	0.9997	0.0016
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0552	0.0523	0.0000	0.0006
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	0.0001	0.0000

FLOW SUMMARIES

Stream No.	5122	5123	5124	5125
Stream Name				
Temp C	39.9983	43.3789	48.1183	37.0000
Pres Pa	109115.3359	109115.3359	109115.3359	109115.3359
Enth kW	-2.0013E+006	-2.0011E+006	-2.0002E+006	-2.0063E+006
Vapor mass fraction	0.00243698	0.00250437	0.0339221	0.0323828
Total kg/h	498835.	498934.	498934.	498934.
Component mass fractions				
Water	0.8399	0.8334	0.8334	0.8334
Cellulose	0.0621	0.0081	0.0081	0.0081
Xylan	0.0019	0.0004	0.0004	0.0004
Arabinan	0.0001	0.0000	0.0000	0.0000
Mannan	0.0010	0.0002	0.0002	0.0002
Galacatan	0.0003	0.0001	0.0001	0.0001
Alpha-D-Glucose	0.0002	0.0603	0.0000	0.0000
Xylose	0.0037	0.0054	0.0054	0.0054
Arabinose	0.0003	0.0004	0.0004	0.0004
Mannose	0.0005	0.0014	0.0000	0.0000
Galactose	0.0001	0.0004	0.0000	0.0000
Ethanol	0.0150	0.0150	0.0431	0.0431
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0046	0.0046	0.0046	0.0046
Calcium Sulfate	0.0033	0.0033	0.0033	0.0033
Glycerol	0.0147	0.0147	0.0196	0.0196
Lignin	0.0363	0.0363	0.0363	0.0363
Soluble Solids	0.0085	0.0085	0.0085	0.0085
Ash	0.0003	0.0003	0.0003	0.0003
Cell Mass	0.0027	0.0027	0.0039	0.0039
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0020	0.0020	0.0020	0.0020
Air	0.0000	0.0000	0.0000	0.0000
Nitrogen	0.0016	0.0016	0.0016	0.0016
Oxygen	0.0000	0.0000	0.0001	0.0001
Carbon Dioxide	0.0006	0.0006	0.0286	0.0286
Acetaldehyde	0.0000	0.0000	0.0001	0.0001
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0002	0.0000	0.0000

FLOW SUMMARIES

Stream No.	5126	5127	5128	5129
Stream Name				
Temp C	37.0000	37.0000	37.0000	37.0000
Pres Pa	109115.3359	109115.3359	108000.0000	108000.0000
Enth kW	-36243.	-1.9700E+006	-0.147191	-1.9700E+006
Vapor mass fraction	1.0000	0.00000	0.0905251	2.3747E-006
Total kg/h	15386.	483548.	0.	483548.
Component mass fractions				
Water	0.0245	0.8592	0.0000	0.8592
Cellulose	0.0000	0.0083	0.0000	0.0083
Xylan	0.0000	0.0004	0.0000	0.0004
Arabinan	0.0000	0.0000	0.0000	0.0000
Mannan	0.0000	0.0002	0.0000	0.0002
Galacatan	0.0000	0.0001	0.0000	0.0001
Alpha-D-Glucose	0.0000	0.0000	0.0000	0.0000
Xylose	0.0000	0.0056	0.4316	0.0056
Arabinose	0.0000	0.0004	0.0000	0.0004
Mannose	0.0000	0.0000	0.0000	0.0000
Galactose	0.0000	0.0000	0.0000	0.0000
Ethanol	0.0187	0.0438	0.0000	0.0438
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0009	0.0048	0.0000	0.0048
Calcium Sulfate	0.0000	0.0034	0.0000	0.0034
Glycerol	0.0000	0.0202	0.0003	0.0202
Lignin	0.0000	0.0374	0.0000	0.0374
Soluble Solids	0.0000	0.0087	0.0000	0.0087
Ash	0.0000	0.0003	0.0000	0.0003
Cell Mass	0.0000	0.0040	0.3125	0.0040
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0000	0.0021	0.1629	0.0021
Air	0.0000	0.0000	0.0000	0.0000
Nitrogen	0.0511	0.0000	0.0000	0.0000
Oxygen	0.0028	0.0000	0.0000	0.0000
Carbon Dioxide	0.9017	0.0009	0.0000	0.0009
Acetaldehyde	0.0003	0.0001	0.0000	0.0001
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	0.0927	0.0000

FLOW SUMMARIES

Stream No.	5130	5131	5132	5133
Stream Name				
Temp C	37.0000	37.0000	37.0000	20.0000
Pres Pa	108000.0000	108000.0000	108000.0000	452000.0000
Enth kW	0.00193377	-36243.	-1.9700E+006	-181.63
Vapor mass fraction	1.0000	1.0000	0.00000	1.0000
Total kg/h	1.	15386.	483548.	240.
Component mass fractions				
Water	0.0000	0.0245	0.8592	0.0000
Cellulose	0.0000	0.0000	0.0083	0.0000
Xylan	0.0000	0.0000	0.0004	0.0000
Arabinan	0.0000	0.0000	0.0000	0.0000
Mannan	0.0000	0.0000	0.0002	0.0000
Galacatan	0.0000	0.0000	0.0001	0.0000
Alpha-D-Glucose	0.0000	0.0000	0.0000	0.0000
Xylose	0.0000	0.0000	0.0056	0.0000
Arabinose	0.0000	0.0000	0.0004	0.0000
Mannose	0.0000	0.0000	0.0000	0.0000
Galactose	0.0000	0.0000	0.0000	0.0000
Ethanol	0.0000	0.0187	0.0438	0.0000
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0000	0.0009	0.0048	0.0000
Calcium Sulfate	0.0000	0.0000	0.0034	0.0000
Glycerol	0.0000	0.0000	0.0202	0.0000
Lignin	0.0000	0.0000	0.0374	0.0000
Soluble Solids	0.0000	0.0000	0.0087	0.0000
Ash	0.0000	0.0000	0.0003	0.0000
Cell Mass	0.0000	0.0000	0.0040	0.0000
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0000	0.0000	0.0021	0.0000
Air	0.0000	0.0000	0.0000	0.0000
Nitrogen	0.9019	0.0511	0.0000	0.0000
Oxygen	0.0981	0.0028	0.0000	0.0000
Carbon Dioxide	0.0000	0.9017	0.0009	0.0000
Acetaldehyde	0.0000	0.0003	0.0001	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	0.0000	1.0000

FLOW SUMMARIES

Stream No.	5134	5135	5136	6101
Stream Name				
Temp C	20.0000	40.0616	48.1183	87.3270
Pres Pa	452000.0000	109115.3359	109115.3359	94200.0000
Enth kW	-75.262	-2.0014E+006	-2.0002E+006	-77038.
Vapor mass fraction	1.0000	0.00244271	0.0339221	0.00000
Total kg/h	100.	498934.	498934.	18256.
Component mass fractions				
Water	0.0000	0.8398	0.8334	0.9687
Cellulose	0.0000	0.0621	0.0081	0.0000
Xylan	0.0000	0.0019	0.0004	0.0000
Arabinan	0.0000	0.0001	0.0000	0.0000
Mannan	0.0000	0.0010	0.0002	0.0000
Galacatan	0.0000	0.0003	0.0001	0.0000
Alpha-D-Glucose	0.0000	0.0002	0.0000	0.0000
Xylose	0.0000	0.0037	0.0054	0.0000
Arabinose	0.0000	0.0003	0.0004	0.0000
Mannose	0.0000	0.0005	0.0000	0.0000
Galactose	0.0000	0.0001	0.0000	0.0000
Ethanol	0.0000	0.0150	0.0431	0.0000
HMF	0.0000	0.0000	0.0000	0.0016
Furfural	0.0000	0.0046	0.0046	0.0297
Calcium Sulfate	0.0000	0.0033	0.0033	0.0000
Glycerol	0.0000	0.0147	0.0196	0.0000
Lignin	0.0000	0.0363	0.0363	0.0000
Soluble Solids	0.0000	0.0085	0.0085	0.0000
Ash	0.0000	0.0003	0.0003	0.0000
Cell Mass	0.0000	0.0027	0.0039	0.0000
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0000	0.0020	0.0020	0.0000
Air	0.0000	0.0000	0.0000	0.0000
Nitrogen	0.0000	0.0016	0.0016	0.0000
Oxygen	0.0000	0.0000	0.0001	0.0000
Carbon Dioxide	0.0000	0.0006	0.0286	0.0000
Acetaldehyde	0.0000	0.0000	0.0001	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	1.0000	0.0002	0.0000	0.0000

FLOW SUMMARIES

Stream No.	6102	6103	6104	6105
Stream Name				
Temp C	59.2772	100.0000	100.0000	100.0000
Pres Pa	451100.0000	382200.0000	382200.0000	382200.0000
Enth kW	-1.9585E+006	-1.9373E+006	-867.52	-1.9364E+006
Vapor mass fraction	0.00000	0.000742294	1.0000	0.00000
Total kg/h	483548.	483548.	341.	483206.
Component mass fractions				
Water	0.8592	0.8592	0.1243	0.8597
Cellulose	0.0083	0.0083	0.0000	0.0083
Xylan	0.0004	0.0004	0.0000	0.0004
Arabinan	0.0000	0.0000	0.0000	0.0000
Mannan	0.0002	0.0002	0.0000	0.0002
Galacatan	0.0001	0.0001	0.0000	0.0001
Alpha-D-Glucose	0.0000	0.0000	0.0000	0.0000
Xylose	0.0056	0.0056	0.0000	0.0056
Arabinose	0.0004	0.0004	0.0000	0.0004
Mannose	0.0000	0.0000	0.0000	0.0000
Galactose	0.0000	0.0000	0.0000	0.0000
Ethanol	0.0438	0.0438	0.0643	0.0438
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0048	0.0048	0.0031	0.0048
Calcium Sulfate	0.0034	0.0034	0.0000	0.0034
Glycerol	0.0202	0.0202	0.0000	0.0202
Lignin	0.0374	0.0374	0.0000	0.0375
Soluble Solids	0.0087	0.0087	0.0000	0.0087
Ash	0.0003	0.0003	0.0000	0.0003
Cell Mass	0.0040	0.0040	0.0000	0.0040
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0021	0.0021	0.0000	0.0021
Air	0.0000	0.0000	0.0000	0.0000
Nitrogen	0.0000	0.0000	0.0000	0.0000
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0009	0.0009	0.8078	0.0003
Acetaldehyde	0.0001	0.0001	0.0004	0.0001
3-Mth-1-Butanol	0.0000	0.0000	0.0001	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	0.0000	0.0000

FLOW SUMMARIES

Stream No.	6106	6107	6108	6109
Stream Name				
Temp C	100.0000	100.0000	106.0000	37.5636
Pres Pa	126626.0000	126626.0000	126626.0000	108000.0000
Enth kW	-1.8513E+006	-85112.	-85083.	-59209.
Vapor mass fraction	0.00000	0.00000	0.00000	0.999398
Total kg/h	448694.	34359.	34359.	37039.
Component mass fractions				
Water	0.9258	0.0000	0.0000	0.0306
Cellulose	0.0000	0.1173	0.1173	0.0000
Xylan	0.0000	0.0054	0.0054	0.0000
Arabinan	0.0000	0.0004	0.0004	0.0000
Mannan	0.0000	0.0029	0.0029	0.0000
Galacatan	0.0000	0.0008	0.0008	0.0000
Alpha-D-Glucose	0.0000	0.0000	0.0000	0.0000
Xylose	0.0000	0.0784	0.0784	0.0000
Arabinose	0.0000	0.0059	0.0059	0.0000
Mannose	0.0000	0.0000	0.0000	0.0000
Galactose	0.0000	0.0000	0.0000	0.0000
Ethanol	0.0472	0.0000	0.0000	0.0138
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0051	0.0000	0.0000	0.0011
Calcium Sulfate	0.0000	0.0485	0.0485	0.0000
Glycerol	0.0218	0.0000	0.0000	0.0000
Lignin	0.0000	0.5267	0.5267	0.0000
Soluble Solids	0.0000	0.1229	0.1229	0.0000
Ash	0.0000	0.0044	0.0044	0.0000
Cell Mass	0.0000	0.0568	0.0568	0.0000
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0001	0.0001	0.0000
Cellulase	0.0000	0.0296	0.0296	0.0000
Air	0.0000	0.0000	0.0000	0.3201
Nitrogen	0.0000	0.0000	0.0000	0.0424
Oxygen	0.0000	0.0000	0.0000	0.0012
Carbon Dioxide	0.0000	0.0000	0.0000	0.5906
Acetaldehyde	0.0001	0.0000	0.0000	0.0001
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	0.0000	0.0000

FLOW SUMMARIES

Stream No.	6110	6208	6301	6302
Stream Name			cent. feed (bottoms)	
Temp C	100.0000	114.5000	101.9011	100.0000
Pres Pa	126626.0000	623000.0000	108000.0000	126626.0000
Enth kW	-1.8511E+006	-45366.	-1.9251E+006	-353.88
Vapor mass fraction	0.00285547	0.00000	0.0210843	1.0000
Total kg/h	448847.	11419.	467949.	153.
Component mass fractions				
Water	0.9255	0.9115	0.9028	0.0000
Cellulose	0.0000	0.0000	0.0086	0.0000
Xylan	0.0000	0.0000	0.0004	0.0000
Arabinan	0.0000	0.0000	0.0000	0.0000
Mannan	0.0000	0.0000	0.0002	0.0000
Galacatan	0.0000	0.0000	0.0001	0.0000
Alpha-D-Glucose	0.0000	0.0000	0.0000	0.0000
Xylose	0.0000	0.0000	0.0058	0.0000
Arabinose	0.0000	0.0000	0.0004	0.0000
Mannose	0.0000	0.0000	0.0000	0.0000
Galactose	0.0000	0.0000	0.0000	0.0000
Ethanol	0.0472	0.0000	0.0000	0.0000
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0051	0.0885	0.0029	0.0000
Calcium Sulfate	0.0000	0.0000	0.0036	0.0000
Glycerol	0.0218	0.0000	0.0209	0.0000
Lignin	0.0000	0.0000	0.0387	0.0000
Soluble Solids	0.0000	0.0000	0.0090	0.0000
Ash	0.0000	0.0000	0.0003	0.0000
Cell Mass	0.0000	0.0000	0.0042	0.0000
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0000	0.0000	0.0022	0.0000
Air	0.0000	0.0000	0.0000	0.0000
Nitrogen	0.0000	0.0000	0.0000	0.0000
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0003	0.0000	0.0000	0.9019
Acetaldehyde	0.0001	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0981
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	0.0000	0.0000

FLOW SUMMARIES

effluent

Stream No.	6303	6304	6305	6306
Stream Name				
Temp C	100.0000	100.1007	100.4411	81.7201
Pres Pa	108000.0000	452000.0000	452000.0000	452000.0000
Enth kW	-1.7979E+006	-1.7979E+006	-1.8432E+006	-4.2838
Vapor mass fraction	0.00000	0.00000	0.00000	0.00000
Total kg/h	424963.	424963.	436382.	1.
Component mass fractions				
Water	0.9622	0.9622	0.9609	0.9740
Cellulose	0.0005	0.0005	0.0005	0.0003
Xylan	0.0000	0.0000	0.0000	0.0000
Arabinan	0.0000	0.0000	0.0000	0.0000
Mannan	0.0000	0.0000	0.0000	0.0000
Galacatan	0.0000	0.0000	0.0000	0.0000
Alpha-D-Glucose	0.0000	0.0000	0.0000	0.0000
Xylose	0.0061	0.0061	0.0060	0.0037
Arabinose	0.0005	0.0005	0.0004	0.0003
Mannose	0.0000	0.0000	0.0000	0.0000
Galactose	0.0000	0.0000	0.0000	0.0000
Ethanol	0.0000	0.0000	0.0000	0.0000
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0030	0.0030	0.0053	0.0011
Calcium Sulfate	0.0002	0.0002	0.0002	0.0003
Glycerol	0.0222	0.0222	0.0216	0.0173
Lignin	0.0021	0.0021	0.0021	0.0015
Soluble Solids	0.0005	0.0005	0.0005	0.0003
Ash	0.0000	0.0000	0.0000	0.0000
Cell Mass	0.0002	0.0002	0.0002	0.0002
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0024	0.0024	0.0023	0.0008
Air	0.0000	0.0000	0.0000	0.0000
Nitrogen	0.0000	0.0000	0.0000	0.0000
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0000	0.0000	0.0000	0.0000
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	0.0000	0.0000

FLOW SUMMARIES

solids

Stream No.	6307	6308	8101	8102
Stream Name				
Temp C	65.5107	100.0000	87.3783	20.0000
Pres Pa	452000.0000	108000.0000	194200.0000	452000.0000
Enth kW	-12.952	-1.3403E+005	-77037.	-98.243
Vapor mass fraction	0.00000	0.00000	0.00000	1.0000
Total kg/h	3.	42986.	18256.	130.
Component mass fractions				
Water	0.9803	0.3160	0.9687	0.0000
Cellulose	0.0003	0.0891	0.0000	0.0000
Xylan	0.0000	0.0041	0.0000	0.0000
Arabinan	0.0000	0.0003	0.0000	0.0000
Mannan	0.0000	0.0022	0.0000	0.0000
Galacatan	0.0000	0.0006	0.0000	0.0000
Alpha-D-Glucose	0.0000	0.0000	0.0000	0.0000
Xylose	0.0028	0.0021	0.0000	0.0000
Arabinose	0.0002	0.0002	0.0000	0.0000
Mannose	0.0000	0.0000	0.0000	0.0000
Galactose	0.0000	0.0000	0.0000	0.0000
Ethanol	0.0000	0.0000	0.0000	0.0000
HMF	0.0000	0.0000	0.0016	0.0000
Furfural	0.0008	0.0011	0.0297	0.0000
Calcium Sulfate	0.0002	0.0368	0.0000	0.0000
Glycerol	0.0131	0.0077	0.0000	0.0000
Lignin	0.0011	0.4000	0.0000	0.0000
Soluble Solids	0.0003	0.0933	0.0000	0.0000
Ash	0.0000	0.0033	0.0000	0.0000
Cell Mass	0.0002	0.0431	0.0000	0.0000
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0001	0.0000	0.0000
Cellulase	0.0006	0.0000	0.0000	0.0000
Air	0.0000	0.0000	0.0000	0.0000
Nitrogen	0.0000	0.0000	0.0000	0.0000
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0000	0.0000	0.0000	0.0000
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	0.0000	1.0000

FLOW SUMMARIES

Stream No.	8103	8104	8105	8106
Stream Name				
Temp C	98.6932	98.8487	35.0000	35.0000
Pres Pa	108000.0000	411000.0000	342100.0312	342100.0312
Enth kW	-5.3304E+005	-5.3303E+005	-5.4229E+005	-5.3815E+005
Vapor mass fraction	0.000129019	0.00000	0.00000	0.0416084
Total kg/h	126322.	126322.	126322.	126321.
Component mass fractions				
Water	0.9610	0.9610	0.9610	0.9514
Cellulose	0.0004	0.0004	0.0004	0.0000
Xylan	0.0000	0.0000	0.0000	0.0000
Arabinan	0.0000	0.0000	0.0000	0.0000
Mannan	0.0000	0.0000	0.0000	0.0000
Galacatan	0.0000	0.0000	0.0000	0.0000
Alpha-D-Glucose	0.0000	0.0000	0.0000	0.0000
Xylose	0.0051	0.0051	0.0051	0.0005
Arabinose	0.0004	0.0004	0.0004	0.0000
Mannose	0.0000	0.0000	0.0000	0.0000
Galactose	0.0000	0.0000	0.0000	0.0000
Ethanol	0.0000	0.0000	0.0000	0.0000
HMF	0.0002	0.0002	0.0002	0.0000
Furfural	0.0088	0.0088	0.0088	0.0009
Calcium Sulfate	0.0002	0.0002	0.0002	0.0002
Glycerol	0.0185	0.0185	0.0185	0.0018
Lignin	0.0018	0.0018	0.0018	0.0018
Soluble Solids	0.0004	0.0004	0.0004	0.0000
Ash	0.0000	0.0000	0.0000	0.0000
Cell Mass	0.0002	0.0002	0.0002	0.0002
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0020	0.0020	0.0020	0.0002
Air	0.0000	0.0000	0.0000	0.0000
Nitrogen	0.0000	0.0000	0.0000	0.0003
Oxygen	0.0000	0.0000	0.0000	0.0102
Carbon Dioxide	0.0000	0.0000	0.0000	0.0178
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0135
Ammonia	0.0010	0.0010	0.0010	0.0010

FLOW SUMMARIES

Stream No.	8107	8108	8109	8110
Stream Name				
Temp C	35.0000	35.0000	35.0000	35.0000
Pres Pa	342100.0312	342100.0312	101000.0000	101000.0000
Enth kW	-5.3743E+005	-5.3743E+005	-5.3106E+005	-6280.6
Vapor mass fraction	0.0338167	0.0338167	0.00000	1.0000
Total kg/h	126321.	126321.	121863.	4458.
Component mass fractions				
Water	0.9541	0.9541	0.9876	0.0395
Cellulose	0.0000	0.0000	0.0000	0.0000
Xylan	0.0000	0.0000	0.0000	0.0000
Arabinan	0.0000	0.0000	0.0000	0.0000
Mannan	0.0000	0.0000	0.0000	0.0000
Galacatan	0.0000	0.0000	0.0000	0.0000
Alpha-D-Glucose	0.0000	0.0000	0.0000	0.0000
Xylose	0.0005	0.0005	0.0005	0.0000
Arabinose	0.0000	0.0000	0.0000	0.0000
Mannose	0.0000	0.0000	0.0000	0.0000
Galactose	0.0000	0.0000	0.0000	0.0000
Ethanol	0.0000	0.0000	0.0000	0.0000
HMF	0.0000	0.0000	0.0000	0.0005
Furfural	0.0009	0.0009	0.0009	0.0003
Calcium Sulfate	0.0002	0.0002	0.0002	0.0000
Glycerol	0.0018	0.0018	0.0019	0.0000
Lignin	0.0018	0.0018	0.0018	0.0000
Soluble Solids	0.0000	0.0000	0.0000	0.0000
Ash	0.0000	0.0000	0.0000	0.0000
Cell Mass	0.0063	0.0063	0.0065	0.0000
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0002	0.0002	0.0002	0.0000
Air	0.0000	0.0000	0.0000	0.0000
Nitrogen	0.0003	0.0003	0.0000	0.0091
Oxygen	0.0102	0.0102	0.0000	0.2888
Carbon Dioxide	0.0123	0.0123	0.0002	0.3426
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0113	0.0113	0.0000	0.3192
Ammonia	0.0000	0.0000	0.0000	0.0000

FLOW SUMMARIES

Stream No.	8201	8203	8204	8205
Stream Name				
Temp C	20.0000	34.9313	51.6439	51.6439
Pres Pa	404000.0000	102000.0000	102000.0000	102000.0000
Enth kW	-1.1835	-5.3105E+005	-5.3108E+005	-5.3108E+005
Vapor mass fraction	1.0000	0.00650847	0.00868872	0.00868872
Total kg/h	750.	122613.	122712.	122712.
Component mass fractions				
Water	0.0000	0.9815	0.9830	0.9830
Cellulose	0.0000	0.0000	0.0000	0.0000
Xylan	0.0000	0.0000	0.0000	0.0000
Arabinan	0.0000	0.0000	0.0000	0.0000
Mannan	0.0000	0.0000	0.0000	0.0000
Galacatan	0.0000	0.0000	0.0000	0.0000
Alpha-D-Glucose	0.0000	0.0000	0.0000	0.0000
Xylose	0.0000	0.0005	0.0000	0.0000
Arabinose	0.0000	0.0000	0.0000	0.0000
Mannose	0.0000	0.0000	0.0000	0.0000
Galactose	0.0000	0.0000	0.0000	0.0000
Ethanol	0.0000	0.0000	0.0000	0.0000
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0000	0.0009	0.0000	0.0000
Calcium Sulfate	0.0000	0.0002	0.0002	0.0002
Glycerol	0.0000	0.0019	0.0000	0.0000
Lignin	0.0000	0.0018	0.0018	0.0018
Soluble Solids	0.0000	0.0000	0.0000	0.0000
Ash	0.0000	0.0000	0.0000	0.0000
Cell Mass	0.0000	0.0065	0.0064	0.0064
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0000	0.0002	0.0000	0.0000
Air	0.0000	0.0000	0.0000	0.0000
Nitrogen	0.0000	0.0000	0.0000	0.0000
Oxygen	1.0000	0.0061	0.0021	0.0021
Carbon Dioxide	0.0000	0.0002	0.0064	0.0064
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	0.0000	0.0000

FLOW SUMMARIES

Stream No.	8206	8207	8208
Stream Name			
Temp C	20.0000	20.0000	20.0000
Pres Pa	102000.0000	102000.0000	102000.0000
Enth kW	-157.55	-5.3546E+005	-5.2928E+005
Vapor mass fraction	1.0000	0.00000	0.00000
Total kg/h	309.	122402.	120211.
Component mass fractions			
Water	0.0125	0.9855	0.9934
Cellulose	0.0000	0.0000	0.0000
Xylan	0.0000	0.0000	0.0000
Arabinan	0.0000	0.0000	0.0000
Mannan	0.0000	0.0000	0.0000
Galacatan	0.0000	0.0000	0.0000
Alpha-D-Glucose	0.0000	0.0000	0.0000
Xylose	0.0000	0.0000	0.0000
Arabinose	0.0000	0.0000	0.0000
Mannose	0.0000	0.0000	0.0000
Galactose	0.0000	0.0000	0.0000
Ethanol	0.0000	0.0000	0.0000
HMF	0.0000	0.0000	0.0000
Furfural	0.0000	0.0000	0.0000
Calcium Sulfate	0.0000	0.0002	0.0000
Glycerol	0.0000	0.0000	0.0000
Lignin	0.0000	0.0018	0.0001
Soluble Solids	0.0000	0.0000	0.0000
Ash	0.0000	0.0000	0.0000
Cell Mass	0.0000	0.0065	0.0003
Sulfuric Acid	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000
Cellulase	0.0000	0.0000	0.0000
Air	0.0000	0.0000	0.0000
Nitrogen	0.0000	0.0000	0.0000
Oxygen	0.7998	0.0000	0.0000
Carbon Dioxide	0.1839	0.0060	0.0061
Acetaldehyde	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000
Methane	0.0036	0.0000	0.0000
Ammonia	0.0002	0.0000	0.0000

HEATING CURVES SUMMARY

Eqp # 18 Unit type : HTXR Unit name: TT-220

Stream 2205

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	102.1	522000.0	3.12E+004	0	467423	0.0000	0.0000
2	98.7	518373.7	2.96E+004	0	467423	0.0000	0.0000
3	95.3	514747.4	2.79E+004	0	467423	0.0000	0.0000
4	91.8	511121.1	2.63E+004	0	467423	0.0000	0.0000
5	88.4	507494.7	2.46E+004	0	467423	0.0000	0.0000
6	85.0	503868.4	2.30E+004	0	467423	0.0000	0.0000
7	81.6	500242.1	2.13E+004	0	467423	0.0000	0.0000
8	78.1	496615.8	1.97E+004	0	467423	0.0000	0.0000
9	74.7	492989.5	1.80E+004	0	467423	0.0000	0.0000
10	71.3	489363.2	1.64E+004	0	467423	0.0000	0.0000
11	67.8	485736.9	1.47E+004	0	467423	0.0000	0.0000
12	64.4	482110.5	1.31E+004	0	467423	0.0000	0.0000
13	61.0	478484.2	1.15E+004	0	467423	0.0000	0.0000
14	57.6	474857.9	9.81E+003	0	467423	0.0000	0.0000
15	54.1	471231.6	8.18E+003	0	467423	0.0000	0.0000
16	50.7	467605.3	6.54E+003	0	467423	0.0000	0.0000
17	47.3	463979.0	4.90E+003	0	467423	0.0000	0.0000
18	43.9	460352.6	3.27E+003	0	467423	0.0000	0.0000
19	40.4	456726.3	1.63E+003	0	467423	0.0000	0.0000
20	37.0	453100.0	0.000	0	467423	0.0000	0.0000

Eqp # 20 Unit type : HTXR Unit name: TT-301A

Stream 3101

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	100.4	452000.0	1.82E+003	0	25000	0.0000	0.0000
2	97.1	448373.7	1.73E+003	0	25000	0.0000	0.0000
3	93.8	444747.4	1.63E+003	0	25000	0.0000	0.0000
4	90.4	441121.0	1.53E+003	0	25000	0.0000	0.0000
5	87.1	437494.7	1.44E+003	0	25000	0.0000	0.0000
6	83.7	433868.4	1.34E+003	0	25000	0.0000	0.0000
7	80.4	430242.1	1.24E+003	0	25000	0.0000	0.0000
8	77.1	426615.8	1.15E+003	0	25000	0.0000	0.0000
9	73.7	422989.5	1.05E+003	0	25000	0.0000	0.0000
10	70.4	419363.2	957.	0	25000	0.0000	0.0000
11	67.1	415736.8	861.	0	25000	0.0000	0.0000
12	63.7	412110.5	765.	0	25000	0.0000	0.0000
13	60.4	408484.2	669.	0	25000	0.0000	0.0000
14	57.0	404857.9	574.	0	25000	0.0000	0.0000
15	53.7	401231.6	478.	0	25000	0.0000	0.0000
16	50.4	397605.2	382.	0	25000	0.0000	0.0000
17	47.0	393978.9	287.	0	25000	0.0000	0.0000
18	43.7	390352.6	191.	0	25000	0.0000	0.0000
19	40.3	386726.3	95.8	0	25000	0.0000	0.0000
20	37.0	383100.0	0.2063	0	25000	0.0000	0.0000

HEATING CURVES SUMMARY

Eqp # 26 Unit type : HTXR Unit name: COILS

Stream 3122

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	50.0	108218.6	1.19E+003	20156	42358	0.2522	0.3224
2	49.3	108218.6	1.12E+003	20100	42415	0.2511	0.3215
3	48.6	108218.6	1.05E+003	20045	42469	0.2500	0.3206
4	47.9	108218.6	978.	19993	42522	0.2490	0.3198
5	47.2	108218.6	910.	19942	42572	0.2481	0.3190
6	46.6	108218.6	842.	19893	42621	0.2471	0.3182
7	45.9	108218.6	776.	19846	42668	0.2462	0.3175
8	45.2	108218.6	711.	19801	42714	0.2454	0.3167
9	44.5	108218.6	647.	19757	42757	0.2446	0.3160
10	43.8	108218.6	584.	19715	42800	0.2438	0.3154
11	43.1	108218.6	522.	19674	42840	0.2430	0.3147
12	42.5	108218.6	460.	19635	42879	0.2422	0.3141
13	41.8	108218.6	400.	19597	42917	0.2415	0.3135
14	41.1	108218.6	340.	19561	42954	0.2408	0.3129
15	40.4	108218.6	282.	19526	42989	0.2402	0.3123
16	39.7	108218.6	224.	19492	43023	0.2395	0.3118
17	39.0	108218.6	167.	19459	43055	0.2389	0.3113
18	38.4	108218.6	111.	19428	43087	0.2383	0.3108
19	37.7	108218.6	54.9	19397	43117	0.2377	0.3103
20	37.0	108218.6	0.000	19368	43146	0.2372	0.3098

Eqp # 36 Unit type : HTXR Unit name: COILS

Stream 3123

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	57.2	108083.9	9.89E+003	7913	473759	0.0088	0.0164
2	56.1	104457.6	9.36E+003	7899	473773	0.0088	0.0164
3	55.1	100831.3	8.83E+003	7886	473786	0.0088	0.0164
4	54.0	97205.0	8.31E+003	7874	473797	0.0087	0.0163
5	52.9	93578.6	7.78E+003	7864	473807	0.0087	0.0163
6	51.9	89952.3	7.25E+003	7855	473816	0.0087	0.0163
7	50.8	86326.0	6.72E+003	7848	473823	0.0087	0.0163
8	49.8	82699.7	6.20E+003	7842	473829	0.0087	0.0163
9	48.7	79073.4	5.67E+003	7838	473833	0.0086	0.0163
10	47.6	75447.1	5.15E+003	7836	473835	0.0086	0.0163
11	46.6	71820.8	4.63E+003	7836	473835	0.0086	0.0163
12	45.5	68194.4	4.11E+003	7839	473833	0.0086	0.0163
13	44.4	64568.1	3.59E+003	7843	473828	0.0086	0.0163
14	43.4	60941.8	3.07E+003	7851	473821	0.0087	0.0163
15	42.3	57315.5	2.55E+003	7862	473810	0.0087	0.0163
16	41.3	53689.2	2.03E+003	7876	473795	0.0087	0.0164
17	40.2	50062.9	1.52E+003	7895	473777	0.0087	0.0164
18	39.1	46436.5	1.01E+003	7919	473753	0.0088	0.0164
19	38.1	42810.2	503.	7949	473722	0.0088	0.0165
20	37.0	39183.9	0.000	7988	473684	0.0089	0.0166

HEATING CURVES SUMMARY

Eqp # 40 Unit type : HTXR Unit name: TT-401A

Stream 4101

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	100.4	452000.0	3.46	0	46	0.0000	0.0000
2	97.0	448373.7	3.27	0	46	0.0000	0.0000
3	93.6	444747.4	3.09	0	46	0.0000	0.0000
4	90.1	441121.0	2.91	0	46	0.0000	0.0000
5	86.7	437494.7	2.73	0	46	0.0000	0.0000
6	83.2	433868.4	2.54	0	46	0.0000	0.0000
7	79.8	430242.1	2.36	0	46	0.0000	0.0000
8	76.3	426615.8	2.18	0	46	0.0000	0.0000
9	72.9	422989.5	2.00	0	46	0.0000	0.0000
10	69.4	419363.2	1.82	0	46	0.0000	0.0000
11	66.0	415736.8	1.63	0	46	0.0000	0.0000
12	62.6	412110.5	1.45	0	46	0.0000	0.0000
13	59.1	408484.2	1.27	0	46	0.0000	0.0000
14	55.7	404857.9	1.09	0	46	0.0000	0.0000
15	52.2	401231.6	0.9074	0	46	0.0000	0.0000
16	48.8	397605.2	0.7259	0	46	0.0000	0.0000
17	45.3	393978.9	0.5445	0	46	0.0000	0.0000
18	41.9	390352.6	0.3631	0	46	0.0000	0.0000
19	38.4	386726.3	0.1817	0	46	0.0000	0.0000
20	35.0	383100.0	0.0003847	0	46	0.0000	0.0000

Eqp # 41 Unit type : HTXR Unit name: TT-401B

Stream 4102

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	35.0	383100.0	0.3686	0	46	0.0000	0.0000
2	34.6	379473.7	0.3492	0	46	0.0000	0.0000
3	34.3	375847.3	0.3298	0	46	0.0000	0.0000
4	33.9	372221.0	0.3104	0	46	0.0000	0.0000
5	33.5	368594.7	0.2910	0	46	0.0000	0.0000
6	33.2	364968.4	0.2716	0	46	0.0000	0.0000
7	32.8	361342.1	0.2522	0	46	0.0000	0.0000
8	32.4	357715.8	0.2328	0	46	0.0000	0.0000
9	32.1	354089.5	0.2134	0	46	0.0000	0.0000
10	31.7	350463.2	0.1940	0	46	0.0000	0.0000
11	31.3	346836.8	0.1746	0	46	0.0000	0.0000
12	30.9	343210.5	0.1552	0	46	0.0000	0.0000
13	30.6	339584.2	0.1358	0	46	0.0000	0.0000
14	30.2	335957.9	0.1164	0	46	0.0000	0.0000
15	29.8	332331.6	0.09697	0	46	0.0000	0.0000
16	29.5	328705.2	0.07757	0	46	0.0000	0.0000
17	29.1	325078.9	0.05819	0	46	0.0000	0.0000
18	28.7	321452.6	0.03880	0	46	0.0000	0.0000
19	28.4	317826.3	0.01940	0	46	0.0000	0.0000
20	28.0	314200.0	0.000	0	46	0.0000	0.0000

HEATING CURVES SUMMARY

Eqp # 46 Unit type : HTXR Unit name: COILS

Stream 4135

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	67.1	433798.3	21.3	540	64	0.8643	0.8943
2	65.0	433798.3	19.5	538	66	0.8593	0.8910
3	63.0	433798.3	17.9	536	68	0.8547	0.8880
4	60.9	433798.3	16.3	534	69	0.8505	0.8852
5	58.8	433798.3	14.9	533	71	0.8467	0.8827
6	56.8	433798.3	13.5	531	72	0.8431	0.8803
7	54.7	433798.3	12.2	530	73	0.8399	0.8782
8	52.7	433798.3	11.0	529	75	0.8370	0.8763
9	50.6	433798.3	9.80	528	76	0.8343	0.8745
10	48.6	433798.3	8.70	527	77	0.8319	0.8729
11	46.5	433798.3	7.64	526	78	0.8297	0.8714
12	44.4	433798.3	6.64	525	78	0.8276	0.8701
13	42.4	433798.3	5.68	524	79	0.8258	0.8688
14	40.3	433798.3	4.77	524	80	0.8241	0.8677
15	38.3	433798.3	3.89	523	80	0.8226	0.8667
16	36.2	433798.3	3.06	522	81	0.8213	0.8658
17	34.2	433798.3	2.25	522	81	0.8200	0.8650
18	32.1	433798.3	1.48	521	82	0.8189	0.8642
19	30.1	433798.3	0.7211	521	82	0.8178	0.8634
20	28.0	433798.3	0.000	521	83	0.8169	0.8628

Eqp # 52 Unit type : HTXR Unit name: TT-402A

Stream 4118

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	100.4	452000.0	1.13E+003	0	15000	0.0000	0.0000
2	97.0	448373.7	1.07E+003	0	15000	0.0000	0.0000
3	93.6	444747.4	1.01E+003	0	15000	0.0000	0.0000
4	90.1	441121.0	948.	0	15000	0.0000	0.0000
5	86.7	437494.7	889.	0	15000	0.0000	0.0000
6	83.2	433868.4	829.	0	15000	0.0000	0.0000
7	79.8	430242.1	770.	0	15000	0.0000	0.0000
8	76.3	426615.8	711.	0	15000	0.0000	0.0000
9	72.9	422989.5	651.	0	15000	0.0000	0.0000
10	69.4	419363.2	592.	0	15000	0.0000	0.0000
11	66.0	415736.8	533.	0	15000	0.0000	0.0000
12	62.6	412110.5	474.	0	15000	0.0000	0.0000
13	59.1	408484.2	414.	0	15000	0.0000	0.0000
14	55.7	404857.9	355.	0	15000	0.0000	0.0000
15	52.2	401231.6	296.	0	15000	0.0000	0.0000
16	48.8	397605.2	237.	0	15000	0.0000	0.0000
17	45.3	393978.9	178.	0	15000	0.0000	0.0000
18	41.9	390352.6	118.	0	15000	0.0000	0.0000
19	38.4	386726.3	59.3	0	15000	0.0000	0.0000
20	35.0	383100.0	0.1266	0	15000	0.0000	0.0000

HEATING CURVES SUMMARY

Eqp # 53 Unit type : HTXR Unit name: TT-402B

Stream 4119

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	35.0	383100.0	137.	0	15000	0.0000	0.0000
2	34.6	379473.7	130.	0	15000	0.0000	0.0000
3	34.2	375847.3	123.	0	15000	0.0000	0.0000
4	33.7	372221.0	116.	0	15000	0.0000	0.0000
5	33.3	368594.7	108.	0	15000	0.0000	0.0000
6	32.9	364968.4	101.	0	15000	0.0000	0.0000
7	32.5	361342.1	94.0	0	15000	0.0000	0.0000
8	32.1	357715.8	86.7	0	15000	0.0000	0.0000
9	31.6	354089.5	79.5	0	15000	0.0000	0.0000
10	31.2	350463.2	72.3	0	15000	0.0000	0.0000
11	30.8	346836.8	65.1	0	15000	0.0000	0.0000
12	30.4	343210.5	57.8	0	15000	0.0000	0.0000
13	29.9	339584.2	50.6	0	15000	0.0000	0.0000
14	29.5	335957.9	43.4	0	15000	0.0000	0.0000
15	29.1	332331.6	36.1	0	15000	0.0000	0.0000
16	28.7	328705.2	28.9	0	15000	0.0000	0.0000
17	28.3	325078.9	21.7	0	15000	0.0000	0.0000
18	27.8	321452.6	14.5	0	15000	0.0000	0.0000
19	27.4	317826.3	7.23	0	15000	0.0000	0.0000
20	27.0	314200.0	0.000	0	15000	0.0000	0.0000

Eqp # 60 Unit type : HTXR Unit name: COILS

Stream 4125

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	59.2	109652.3	3.14E+003	32508	21344	0.5200	0.6036
2	57.5	109652.3	2.87E+003	32177	21676	0.5120	0.5975
3	55.9	109652.3	2.62E+003	31875	21977	0.5047	0.5919
4	54.3	109652.3	2.38E+003	31601	22251	0.4981	0.5868
5	52.6	109652.3	2.16E+003	31351	22502	0.4921	0.5822
6	51.0	109652.3	1.96E+003	31122	22730	0.4865	0.5779
7	49.3	109652.3	1.77E+003	30913	22939	0.4815	0.5740
8	47.7	109652.3	1.58E+003	30722	23131	0.4769	0.5705
9	46.1	109652.3	1.41E+003	30547	23306	0.4727	0.5672
10	44.4	109652.3	1.25E+003	30386	23466	0.4689	0.5643
11	42.8	109652.3	1.10E+003	30239	23613	0.4653	0.5615
12	41.1	109652.3	952.	30105	23747	0.4621	0.5590
13	39.5	109652.3	814.	29981	23871	0.4591	0.5567
14	37.8	109652.3	682.	29868	23984	0.4564	0.5546
15	36.2	109652.3	556.	29765	24087	0.4540	0.5527
16	34.6	109652.3	436.	29670	24182	0.4517	0.5509
17	32.9	109652.3	321.	29583	24270	0.4496	0.5493
18	31.3	109652.3	211.	29503	24349	0.4477	0.5478
19	29.6	109652.3	102.	29402	24450	0.4457	0.5460
20	28.0	109652.3	0.000	29334	24518	0.4441	0.5447

HEATING CURVES SUMMARY

Eqp # 75 Unit type : HTXR Unit name: COILS

Stream 5112

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	47.7	109069.5	1.46E+003	15448	98339	0.1040	0.1358
2	47.1	109069.5	1.38E+003	15411	98376	0.1037	0.1354
3	46.6	109069.5	1.30E+003	15375	98412	0.1034	0.1351
4	46.0	109069.5	1.22E+003	15340	98446	0.1030	0.1348
5	45.4	109069.5	1.14E+003	15307	98480	0.1027	0.1345
6	44.9	109069.5	1.06E+003	15274	98513	0.1024	0.1342
7	44.3	109069.5	979.	15242	98545	0.1021	0.1339
8	43.7	109069.5	901.	15210	98576	0.1018	0.1337
9	43.2	109069.5	824.	15180	98607	0.1015	0.1334
10	42.6	109069.5	746.	15151	98636	0.1012	0.1332
11	42.1	109069.5	670.	15122	98665	0.1010	0.1329
12	41.5	109069.5	594.	15095	98692	0.1007	0.1327
13	40.9	109069.5	518.	15068	98719	0.1005	0.1324
14	40.4	109069.5	443.	15042	98745	0.1002	0.1322
15	39.8	109069.5	368.	15016	98771	0.1000	0.1320
16	39.2	109069.5	294.	14991	98796	0.0997	0.1317
17	38.7	109069.5	220.	14967	98820	0.0995	0.1315
18	38.1	109069.5	146.	14944	98843	0.0993	0.1313
19	37.6	109069.5	72.8	14921	98866	0.0991	0.1311
20	37.0	109069.5	0.000	14899	98888	0.0989	0.1309

Eqp # 86 Unit type : HTXR Unit name: COILS

Stream 5136

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	48.1	109115.3	6.09E+003	16118	482817	0.0166	0.0323
2	47.5	109115.3	5.76E+003	16071	482863	0.0165	0.0322
3	46.9	109115.3	5.44E+003	16026	482908	0.0165	0.0321
4	46.4	109115.3	5.11E+003	15982	482953	0.0164	0.0320
5	45.8	109115.3	4.79E+003	15938	482996	0.0163	0.0319
6	45.2	109115.3	4.47E+003	15896	483038	0.0163	0.0319
7	44.6	109115.3	4.14E+003	15855	483080	0.0162	0.0318
8	44.0	109115.3	3.82E+003	15814	483120	0.0161	0.0317
9	43.4	109115.3	3.50E+003	15775	483160	0.0161	0.0316
10	42.9	109115.3	3.18E+003	15736	483198	0.0160	0.0315
11	42.3	109115.3	2.86E+003	15698	483236	0.0159	0.0315
12	41.7	109115.3	2.54E+003	15661	483274	0.0159	0.0314
13	41.1	109115.3	2.22E+003	15624	483310	0.0158	0.0313
14	40.5	109115.3	1.90E+003	15588	483346	0.0158	0.0312
15	39.9	109115.3	1.59E+003	15553	483381	0.0157	0.0312
16	39.3	109115.3	1.27E+003	15519	483416	0.0157	0.0311
17	38.8	109115.3	950.	15485	483450	0.0156	0.0310
18	38.2	109115.3	633.	15451	483483	0.0156	0.0310
19	37.6	109115.3	316.	15419	483516	0.0155	0.0309
20	37.0	109115.3	0.000	15386	483548	0.0155	0.0308

HEATING CURVES SUMMARY

Eqp # 93 Unit type : HTXR Unit name: TT-615

Stream 510

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	37.1	520000.0	3.90	0	483548	0.0000	0.0000
2	38.3	516373.7	605.	0	483548	0.0000	0.0000
3	39.5	512747.4	1.21E+003	0	483548	0.0000	0.0000
4	40.6	509121.0	1.81E+003	0	483548	0.0000	0.0000
5	41.8	505494.7	2.41E+003	0	483548	0.0000	0.0000
6	43.0	501868.4	3.01E+003	0	483548	0.0000	0.0000
7	44.1	498242.1	3.61E+003	0	483548	0.0000	0.0000
8	45.3	494615.8	4.21E+003	0	483548	0.0000	0.0000
9	46.5	490989.5	4.82E+003	0	483548	0.0000	0.0000
10	47.6	487363.2	5.42E+003	0	483548	0.0000	0.0000
11	48.8	483736.9	6.02E+003	0	483548	0.0000	0.0000
12	50.0	480110.5	6.62E+003	0	483548	0.0000	0.0000
13	51.1	476484.2	7.22E+003	0	483548	0.0000	0.0000
14	52.3	472857.9	7.83E+003	0	483548	0.0000	0.0000
15	53.5	469231.6	8.43E+003	0	483548	0.0000	0.0000
16	54.6	465605.3	9.03E+003	0	483548	0.0000	0.0000
17	55.8	461979.0	9.63E+003	0	483548	0.0000	0.0000
18	56.9	458352.6	1.02E+004	0	483548	0.0000	0.0000
19	58.1	454726.3	1.08E+004	0	483548	0.0000	0.0000
20	59.3	451100.0	1.14E+004	0	483548	0.0000	0.0000

Stream 216

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	102.0	108000.0	1.14E+004	18256	0	1.0000	1.0000
2	101.2	107273.7	2.54E+003	3845	14410	0.2014	0.2106
3	100.5	106547.4	446.	321	17935	0.0151	0.0176
4	99.7	105821.0	328.	141	18115	0.0061	0.0077
5	98.9	105094.7	284.	91	18165	0.0036	0.0050
6	98.1	104368.4	255.	67	18188	0.0025	0.0037
7	97.4	103642.1	232.	53	18203	0.0018	0.0029
8	96.6	102915.8	210.	43	18213	0.0014	0.0023
9	95.8	102189.5	191.	35	18220	0.0011	0.0019
10	95.0	101463.2	172.	29	18226	0.0008	0.0016
11	94.3	100736.8	154.	24	18231	0.0007	0.0013
12	93.5	100010.5	136.	20	18236	0.0005	0.0011
13	92.7	99284.2	118.	16	18239	0.0004	0.0009
14	92.0	98557.9	101.	13	18243	0.0003	0.0007
15	91.2	97831.6	83.6	9	18246	0.0002	0.0005
16	90.4	97105.3	66.5	6	18249	0.0001	0.0003
17	89.6	96378.9	49.5	3	18252	0.0001	0.0002
18	88.9	95652.6	32.5	1	18255	0.0000	0.0000
19	88.1	94926.3	16.2	0	18256	0.0000	0.0000
20	87.3	94200.0	0.000	0	18256	0.0000	0.0000

HEATING CURVES SUMMARY

Eqp # 94 Unit type : HTXR Unit name: TT-613

Stream 6102

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	59.3	451100.0	0.000	0	483548	0.0000	0.0000
2	61.4	447473.7	1.11E+003	0	483548	0.0000	0.0000
3	63.6	443847.4	2.22E+003	0	483548	0.0000	0.0000
4	65.7	440221.1	3.33E+003	0	483548	0.0000	0.0000
5	67.9	436594.8	4.44E+003	0	483548	0.0000	0.0000
6	70.0	432968.4	5.55E+003	0	483548	0.0000	0.0000
7	72.1	429342.1	6.66E+003	0	483548	0.0000	0.0000
8	74.3	425715.8	7.77E+003	0	483548	0.0000	0.0000
9	76.4	422089.5	8.89E+003	0	483548	0.0000	0.0000
10	78.6	418463.2	1.00E+004	26	483522	0.0000	0.0001
11	80.7	414836.8	1.11E+004	65	483483	0.0001	0.0001
12	82.9	411210.5	1.22E+004	101	483447	0.0001	0.0002
13	85.0	407584.2	1.34E+004	135	483412	0.0001	0.0003
14	87.1	403957.9	1.45E+004	168	483380	0.0002	0.0003
15	89.3	400331.6	1.56E+004	199	483349	0.0002	0.0004
16	91.4	396705.3	1.67E+004	229	483319	0.0002	0.0005
17	93.6	393079.0	1.78E+004	257	483290	0.0003	0.0005
18	95.7	389452.6	1.90E+004	286	483262	0.0003	0.0006
19	97.9	385826.3	2.01E+004	313	483234	0.0003	0.0006
20	100.0	382200.0	2.12E+004	341	483206	0.0004	0.0007

Eqp # 97 Unit type : HTXR Unit name: (REBOILER)

Stream 6107

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	100.0	126626.0	0.000	0	34359	0.0000	0.0000
2	100.3	126626.0	1.53	0	34359	0.0000	0.0000
3	100.6	126626.0	3.06	0	34359	0.0000	0.0000
4	100.9	126626.0	4.59	0	34359	0.0000	0.0000
5	101.3	126626.0	6.11	0	34359	0.0000	0.0000
6	101.6	126626.0	7.64	0	34359	0.0000	0.0000
7	101.9	126626.0	9.17	0	34359	0.0000	0.0000
8	102.2	126626.0	10.7	0	34359	0.0000	0.0000
9	102.5	126626.0	12.2	0	34359	0.0000	0.0000
10	102.8	126626.0	13.8	0	34359	0.0000	0.0000
11	103.2	126626.0	15.3	0	34359	0.0000	0.0000
12	103.5	126626.0	16.8	0	34359	0.0000	0.0000
13	103.8	126626.0	18.4	0	34359	0.0000	0.0000
14	104.1	126626.0	19.9	0	34359	0.0000	0.0000
15	104.4	126626.0	21.4	0	34359	0.0000	0.0000
16	104.7	126626.0	23.0	0	34359	0.0000	0.0000
17	105.1	126626.0	24.5	0	34359	0.0000	0.0000
18	105.4	126626.0	26.1	0	34359	0.0000	0.0000
19	105.7	126626.0	27.6	0	34359	0.0000	0.0000
20	106.0	126626.0	29.1	0	34359	0.0000	0.0000

HEATING CURVES SUMMARY

Eqp # 112 Unit type : HTXR Unit name: TT-802

Stream 8104

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	98.8	411000.0	9.26E+003	0	126322	0.0000	0.0000
2	95.5	407373.7	8.77E+003	0	126322	0.0000	0.0000
3	92.1	403747.4	8.28E+003	0	126322	0.0000	0.0000
4	88.8	400121.1	7.79E+003	0	126322	0.0000	0.0000
5	85.4	396494.8	7.30E+003	0	126322	0.0000	0.0000
6	82.0	392868.4	6.81E+003	0	126322	0.0000	0.0000
7	78.7	389242.1	6.32E+003	0	126322	0.0000	0.0000
8	75.3	385615.8	5.84E+003	0	126322	0.0000	0.0000
9	72.0	381989.5	5.35E+003	0	126322	0.0000	0.0000
10	68.6	378363.2	4.86E+003	0	126322	0.0000	0.0000
11	65.2	374736.8	4.38E+003	0	126322	0.0000	0.0000
12	61.9	371110.5	3.89E+003	0	126322	0.0000	0.0000
13	58.5	367484.2	3.40E+003	0	126322	0.0000	0.0000
14	55.2	363857.9	2.92E+003	0	126322	0.0000	0.0000
15	51.8	360231.6	2.43E+003	0	126322	0.0000	0.0000
16	48.4	356605.3	1.94E+003	0	126322	0.0000	0.0000
17	45.1	352979.0	1.46E+003	0	126322	0.0000	0.0000
18	41.7	349352.6	971.	0	126322	0.0000	0.0000
19	38.4	345726.3	486.	0	126322	0.0000	0.0000
20	35.0	342100.0	0.000	0	126322	0.0000	0.0000

Job Name: BOIL-BAS

Date: 07-07-94 Time: 15:06

FLOWSHEET SUMMARY

Equipment	Label	Stream Numbers
1 MIXE		3113 4113 419 6302 813 -8301
2 MIXE		631 821 6213 -8304
3 COMP	PB-817	8301 -8302
4 MIXE		6411 8302 -8303

Stream Connections

Stream	Equipment From	Equipment To	Stream	Equipment From	Equipment To	Stream	Equipment From	Equipment To
419		1	4113		1	8302	3	4
631		2	6213		2	8303	4	
813		1	6302		1	8304	2	
821		2	6411		4			
3113		1	8301	1	3			

Equipment Calculation Sequence
1 2 3 4

No recycle loops in the flowsheet.

COMPONENTS

	ID #	Name
1	62	Water
2	8003	Cellulose
3	8004	Xylan
4	8008	Arabinan
5	8009	Mannan
6	8010	Galacatan
7	776	Alpha-D-Glucose
8	8001	Xylose
9	8005	Arabinose
10	8006	Mannose
11	8007	Galactose
12	134	Ethanol
13	8002	HMF
14	164	Furfural
15	931	Calcium Sulfate
16	268	Glycerol
17	8011	Lignin
18	8016	Soluble Solids
19	8013	Ash
20	8014	Cell Mass

21	431	Sulfuric Acid
22	929	CalciumHydroxide
23	8015	Cellulase
24	475	Air
25	46	Nitrogen
26	47	Oxygen
27	49	Carbon Dioxide
28	128	Acetaldehyde
29	315	3-Mth-1-Butanol
30	2	Methane
31	63	Ammonia

THERMODYNAMICS

K-value model : NRTL
No corrrection for vapor fugacity
Enthalpy model : Heat of Vaporization (Latent Heat)
Liquid density : Library

NRTL Parameters:

I	J	Bij	Bji	Alpha
1	12	670.441	-55.168	0.303
1	16	258.114	-274.349	1.011
1	21	-1228.663	-1894.248	0.243
1	28	662.993	-23.571	0.287
1	29	1828.452	-249.014	0.282
12	14	510.442	328.316	0.777
12	16	398.444	79.505	0.296
12	28	195.116	-553.744	0.409
12	29	25.750	-21.569	0.301
30	31	-0.131	237.017	0.000

Warning : BIP matrix is less than 50 % full.

Overall Mass Balance	kmol/h		kg/h	
	Input	Output	Input	Output
Water	946.267	946.267	17046.999	17046.999
Cellulose	23.615	23.615	3829.000	3829.000
Xylan	1.325	1.325	175.000	175.000
Arabinan	0.098	0.098	13.000	13.000
Mannan	0.574	0.574	93.000	93.000
Galacatan	0.167	0.167	27.000	27.000
Alpha-D-Glucose	0.000	0.000	0.000	0.000
Xylose	0.613	0.613	92.000	92.000
Arabinose	0.047	0.047	7.000	7.000
Mannose	0.000	0.000	0.000	0.000
Galactose	0.000	0.000	0.000	0.000
Ethanol	9.963	9.963	459.000	459.000
HMF	0.016	0.016	2.000	2.000
Furfural	0.968	0.968	93.000	93.000
Calcium Sulfate	11.774	11.774	1603.000	1603.000
Glycerol	3.605	3.605	332.000	332.000
Lignin	142.322	142.322	17405.999	17405.999
Soluble Solids	2.425	2.425	4012.000	4012.000
Ash	1.186	1.186	145.000	145.000
Cell Mass	1.126	1.126	2603.000	2603.000
Sulfuric Acid	0.000	0.000	0.000	0.000
CalciumHydroxide	0.040	0.040	3.000	3.000
Cellulase	0.000	0.000	0.000	0.000
Air	1842.182	1842.182	53332.999	53332.999
Nitrogen	215.178	215.178	6028.007	6028.007
Oxygen	1.353	1.353	43.308	43.308
Carbon Dioxide	544.111	544.111	23946.322	23946.322
Acetaldehyde	0.136	0.136	6.000	6.000
3-Mth-1-Butanol	0.170	0.170	15.000	15.000
Methane	0.020	0.020	0.323	0.323
Ammonia	0.000	0.000	0.000	0.000
Total	3749.280	3749.280	131312.964	131312.964

EQUIPMENT SUMMARIES

Mixer Summary

Equip. No.	1	2	4
Name			
Output Pressure Pa	101000.0000	108000.0000	111000.0000

Compressor Summary

Equip. No.	3
Name	PB-817
Type of Compressor:	1
Pressure out Pa	111000.0000
Efficiency	0.8500
Actual power kW	138.6532
Cp/Cv	1.3907
Ideal Cp/Cv	1.3917
Theoretical power kW	117.8552

STREAM PROPERTIES

Stream No.	419	631	813	821
Name				
- - Overall - -				
Mass flow kg/h	29373.	42984.	180.	2192.
Temp C	28.	100.	41.	20.
Pres Pa	108000.	108000.	108000.	102000.
Vapor mass fraction	0.99883	0.0000	0.0054478	0.0000
Enth kW	-5991.	-2.193E+005	-775.8	-5983.
Std. sp gr , wtr = 1	0.856	1.329	0.998	1.042
Std. sp gr , air = 1	1.000	1.577	0.632	1.094
Average mol wt	29.	46.	18.	32.
Actual vol m3/h	23459.	30.	1.	1.
RVP Pa		5196.113	136463.016	6354.029

STREAM PROPERTIES

Stream No.	3113	4113	6213	6302
Name				
- - Overall - -				
Mass flow kg/h	19370.	529.	458.	153.
Temp C	37.	28.	80.	100.
Pres Pa	108000.	108000.	540000.	126626.
Vapor mass fraction	0.99803	0.99941	0.0000	1.000
Enth kW	-3786.	-61.92	-810.1	-353.7
Std. sp gr , wtr = 1	0.863	0.862	0.804	0.826
Std. sp gr , air = 1	0.985	0.989	1.470	1.598
Average mol wt	29.	29.	43.	46.
Actual vol m3/h	16157.	427.	1.	81.
RVP Pa			15930.727	69706712.000

STREAM PROPERTIES

Stream No.	6411	8301	8302	8303
Name				
- - Overall - -				
Mass flow kg/h	36074.	49605.	49605.	85679.
Temp C	39.	31.	34.	34.
Pres Pa	108000.	101000.	111000.	111000.
Vapor mass fraction	1.000	0.99502	0.99811	1.000
Enth kW	-5.677E+004	-1.097E+004	-1.083E+004	-6.760E+004
Std. sp gr , wtr = 1	0.840	0.859	0.859	0.851
Std. sp gr , air = 1	1.241	0.993	0.993	1.084
Average mol wt	36.	29.	29.	31.
Actual vol m3/h	24052.	42807.	39594.	62716.
RVP Pa				

STREAM PROPERTIES

Stream No.	8304
Name	
- - Overall - -	
Mass flow kg/h	45634.
Temp C	94.
Pres Pa	108000.
Vapor mass fraction	0.0000
Enth kW	-2.261E+005
Std. sp gr , wtr = 1	1.303
Std. sp gr , air = 1	1.543
Average mol wt	45.
Actual vol m3/h	31.
RVP Pa	5635.472

FLOW SUMMARIES

Stream No.	419	631	813	821
Stream Name				
Temp C	28.0000	100.0000	40.9000	20.0000
Pres Pa	108000.0000	108000.0000	108000.0000	102000.0000
Enth kW	-5991.2	-2.1933E+005	-775.81	-5982.7
Vapor mass fraction	0.998828	0.00000	0.00544782	0.00000
Total kg/h	29373.	42984.	180.	2192.
Component mass fractions				
Water	0.0218	0.3160	0.9780	0.5502
Cellulose	0.0000	0.0891	0.0000	0.0000
Xylan	0.0000	0.0041	0.0000	0.0000
Arabinan	0.0000	0.0003	0.0000	0.0000
Mannan	0.0000	0.0022	0.0000	0.0000
Galacatan	0.0000	0.0006	0.0000	0.0000
Alpha-D-Glucose	0.0000	0.0000	0.0000	0.0000
Xylose	0.0000	0.0021	0.0000	0.0000
Arabinose	0.0000	0.0002	0.0000	0.0000
Mannose	0.0000	0.0000	0.0000	0.0000
Galactose	0.0000	0.0000	0.0000	0.0000
Ethanol	0.0000	0.0000	0.0000	0.0000
HMF	0.0000	0.0000	0.0111	0.0000
Furfural	0.0007	0.0010	0.0056	0.0000
Calcium Sulfate	0.0000	0.0368	0.0000	0.0091
Glycerol	0.0000	0.0077	0.0000	0.0000
Lignin	0.0000	0.4000	0.0000	0.0972
Soluble Solids	0.0000	0.0933	0.0000	0.0000
Ash	0.0000	0.0033	0.0000	0.0009
Cell Mass	0.0000	0.0431	0.0000	0.3426
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0001	0.0000	0.0000
Cellulase	0.0000	0.0000	0.0000	0.0000
Air	0.8125	0.0000	0.0000	0.0000
Nitrogen	0.1156	0.0000	0.0000	0.0000
Oxygen	0.0000	0.0000	0.0017	0.0000
Carbon Dioxide	0.0494	0.0000	0.0018	0.0000
Acetaldehyde	0.0000	0.0000	0.0000	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0000
Methane	0.0000	0.0000	0.0018	0.0000
Ammonia	0.0000	0.0000	0.0000	0.0000

FLOW SUMMARIES

Stream No.	3113	4113	6213	6302
Stream Name				
Temp C	37.0000	28.0000	80.0000	100.0000
Pres Pa	108000.0000	108000.0000	540000.0000	126626.0000
Enth kW	-3785.7	-61.924	-810.07	-353.66
Vapor mass fraction	0.998032	0.999406	0.00000	1.0000
Total kg/h	19370.	529.	458.	153.
Component mass fractions				
Water	0.0367	0.0227	0.0524	0.0000
Cellulose	0.0000	0.0000	0.0000	0.0000
Xylan	0.0000	0.0000	0.0000	0.0000
Arabinan	0.0000	0.0000	0.0000	0.0000
Mannan	0.0000	0.0000	0.0000	0.0000
Galacatan	0.0000	0.0000	0.0000	0.0000
Alpha-D-Glucose	0.0000	0.0000	0.0000	0.0000
Xylose	0.0000	0.0000	0.0000	0.0000
Arabinose	0.0000	0.0000	0.0000	0.0000
Mannose	0.0000	0.0000	0.0000	0.0000
Galactose	0.0000	0.0000	0.0000	0.0000
Ethanol	0.0000	0.0000	0.9454	0.0000
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0013	0.0000	0.0000	0.0000
Calcium Sulfate	0.0000	0.0000	0.0000	0.0000
Glycerol	0.0000	0.0000	0.0000	0.0000
Lignin	0.0000	0.0000	0.0000	0.0000
Soluble Solids	0.0000	0.0000	0.0000	0.0000
Ash	0.0000	0.0000	0.0000	0.0000
Cell Mass	0.0000	0.0000	0.0000	0.0000
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0000	0.0000	0.0000	0.0000
Air	0.8837	0.9338	0.0000	0.0000
Nitrogen	0.0539	0.0302	0.0000	0.0000
Oxygen	0.0000	0.0000	0.0000	0.0000
Carbon Dioxide	0.0244	0.0132	0.0000	0.9020
Acetaldehyde	0.0000	0.0000	0.0022	0.0000
3-Mth-1-Butanol	0.0000	0.0000	0.0000	0.0980
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	0.0000	0.0000

FLOW SUMMARIES

Stream No.	6411	8301	8302	8303
Stream Name				
Temp C	39.0000	30.7253	34.3464	34.1895
Pres Pa	108000.0000	101000.0000	111000.0000	111000.0000
Enth kW	-56767.	-10968.	-10830.	-67596.
Vapor mass fraction	1.0000	0.995019	0.998105	1.0000
Total kg/h	36074.	49605.	49605.	85679.
Component mass fractions				
Water	0.0193	0.0310	0.0310	0.0261
Cellulose	0.0000	0.0000	0.0000	0.0000
Xylan	0.0000	0.0000	0.0000	0.0000
Arabinan	0.0000	0.0000	0.0000	0.0000
Mannan	0.0000	0.0000	0.0000	0.0000
Galacatan	0.0000	0.0000	0.0000	0.0000
Alpha-D-Glucose	0.0000	0.0000	0.0000	0.0000
Xylose	0.0000	0.0000	0.0000	0.0000
Arabinose	0.0000	0.0000	0.0000	0.0000
Mannose	0.0000	0.0000	0.0000	0.0000
Galactose	0.0000	0.0000	0.0000	0.0000
Ethanol	0.0007	0.0000	0.0000	0.0003
HMF	0.0000	0.0000	0.0000	0.0000
Furfural	0.0000	0.0010	0.0010	0.0006
Calcium Sulfate	0.0000	0.0000	0.0000	0.0000
Glycerol	0.0000	0.0000	0.0000	0.0000
Lignin	0.0000	0.0000	0.0000	0.0000
Soluble Solids	0.0000	0.0000	0.0000	0.0000
Ash	0.0000	0.0000	0.0000	0.0000
Cell Mass	0.0000	0.0000	0.0000	0.0000
Sulfuric Acid	0.0000	0.0000	0.0000	0.0000
CalciumHydroxide	0.0000	0.0000	0.0000	0.0000
Cellulase	0.0000	0.0000	0.0000	0.0000
Air	0.3287	0.8361	0.8361	0.6225
Nitrogen	0.0436	0.0898	0.0898	0.0704
Oxygen	0.0012	0.0000	0.0000	0.0005
Carbon Dioxide	0.6064	0.0417	0.0417	0.2795
Acetaldehyde	0.0001	0.0000	0.0000	0.0001
3-Mth-1-Butanol	0.0000	0.0003	0.0003	0.0002
Methane	0.0000	0.0000	0.0000	0.0000
Ammonia	0.0000	0.0000	0.0000	0.0000

FLOW SUMMARIES

Stream No.	8304
Stream Name	
Temp C	94.2993
Pres Pa	108000.0000
Enth kW	-2.2612E+005
Vapor mass fraction	0.00000
Total kg/h	45634.
Component mass fractions	
Water	0.3246
Cellulose	0.0839
Xylan	0.0038
Arabinan	0.0003
Mannan	0.0020
Galacatan	0.0006
Alpha-D-Glucose	0.0000
Xylose	0.0020
Arabinose	0.0002
Mannose	0.0000
Galactose	0.0000
Ethanol	0.0095
HMF	0.0000
Furfural	0.0010
Calcium Sulfate	0.0351
Glycerol	0.0073
Lignin	0.3814
Soluble Solids	0.0879
Ash	0.0032
Cell Mass	0.0570
Sulfuric Acid	0.0000
CalciumHydroxide	0.0001
Cellulase	0.0000
Air	0.0000
Nitrogen	0.0000
Oxygen	0.0000
Carbon Dioxide	0.0000
Acetaldehyde	0.0000
3-Mth-1-Butanol	0.0000
Methane	0.0000
Ammonia	0.0000

APPENDIX II
DISTILLATION AREA

Job Name: ETOH-2

Date: 07-12-94 Time: 09:35

FLOWSHEET SUMMARY

Equipment	Label	Stream Numbers
1 SCDS	AS-601	6204 6206 -6212 -6209
2 SCDS	AS-602	6212 -6215 -6213 -6214
3 HTXR	TT-616	6410 6207 -6205 -6208
4 HTXR	TT-627	6220 -6221
5 HTXR	TT-615	6201 216 -6202 -6207
6 HTXR	TT-613	6203 -6204
7 HTXR	TT-622	6219 6222 -6220 -6223
8 HTXR	TT-624	6223 -6224
9 HTXR	TT-623	6106 6216 -6201 -6217
10 HTXR	TT-626	6217 -6218
11 HTXR		6202 6210 -6203 -6225
12 HTXR	TT-625	6205 6209 -6206 -6210
13 HTXR	TT-628	6225 -6211

Stream Connections

Stream	Equipment From	Equipment To	Stream	Equipment From	Equipment To	Stream	Equipment From	Equipment To
216		5	6209	1	12	6219		7
6106		9	6210	12	11	6220	7	4
6201	9	5	6211	13		6221	4	
6202	5	11	6212	1	2	6222		7
6203	11	6	6213	2		6223	7	8
6204	6	1	6214	2		6224	8	
6205	3	12	6215	2		6225	11	13
6206	12	1	6216		9	6410		3
6207	5	3	6217	9	10			
6208	3		6218	10				

Equipment Calculation Sequence
7 8 9 10 4 5 3 11 6 1 12 2 13

Equipment Recycle Sequence
11 6 1 12

Recycle Cut Streams
6210 6206

Recycle Convergence Method: Direct Substitution

Max. loop iterations 40

Recycle Convergence Tolerance

Flow rate	1.000E-003
Temperature	1.000E-003
Pressure	1.000E-003
Enthalpy	1.000E-003
Vapor frac.	1.000E-003

Recycle calculation has converged.

COMPONENTS

	ID #	Name
1	62	Water
2	134	Ethanol
3	164	Furfural
4	268	Glycerol
5	128	Acetaldehyde

THERMODYNAMICS

K-value model : NRTL
No corrrection for vapor fugacity
Enthalpy model : Heat of Vaporization (Latent Heat)
Liquid density : Library

NRTL Parameters:

I	J	Bij	Bji	Alpha
1	2	670.441	-55.168	0.303
1	3	1584.604	-204.266	0.202
1	4	258.114	-274.349	1.011
1	5	662.993	-23.571	0.287
2	3	510.442	328.316	0.777
2	4	398.444	79.505	0.296
2	5	807.183	-650.026	0.311
3	4	1411.930	-16.983	0.350
3	5	-220.697	737.237	0.399
4	5	-431.380	1380.308	0.400

Overall Mass Balance	kmol/h		kg/h	
	Input	Output	Input	Output
Water	29959.425	29959.425	539719.027	539719.027
Ethanol	4168.573	4168.573	192042.001	192042.001
Furfural	188.841	188.841	18145.000	18145.000
Glycerol	106.054	106.054	9767.000	9767.000
Acetaldehyde	6.674	6.674	294.000	294.000
Total	34429.564	34429.564	759966.970	759966.970

EQUIPMENT SUMMARIES

Scds Rigorous Distillation Summary

Equip. No.	1	2
Name	AS-601	AS-602
TOP pressure Pa	412000.0000	105000.0000
Cond press drop Pa	7000.0000	7000.0000
Colm press drop Pa	44100.0000	63000.0000
No. of stages	40	70
1st feed stage	5	62
2nd feed stage	18	0
Efficiency top stage	0.6000	0.6000
Efficiency bot stage	0.6000	0.6000
Select condenser mode:	1	1
Condenser spec.	2.0000	4.0000
Select reboiler mode:	6	6
Reboiler spec.	1.0000e-004	1.0000e-004
Rebl. comp i	2	2
Side product stage	0	2
Side product spec.		0.0040
Initial flag	1	1
Calc cond duty kW	-32638.0176	-28934.0176
Calc rebr duty kW	47600.8203	28087.9258

Heat Exchanger Summary

Equip. No.	3	4	5	6
Name	TT-616	TT-627	TT-615	TT-613
Pressure drop 1 Pa	69000.0000	3500.0000	69000.0000	69000.0000
Pressure drop 2 Pa			7000.0000	
T Out Str 1 C				120.0000
T Out Str 2 C				186.0000
Min Delta Temp C	5.0000		5.0000	
Heat Duty kW		5060.0000		
U W/m2-K				3975.0000
Calc Ht Duty kW	1270.0756	5060.0000	10802.0059	
LMTD C	11.4964		11.9533	
LMTD Corr F	1.0000		1.0000	

Equip. No.	7	8	9	10
Name	TT-622	TT-624	TT-623	TT-626
Pressure drop 1 Pa	3500.0000	3500.0000	69000.0000	3500.0000
Pressure drop 2 Pa	3500.0000		3500.0000	
Min Delta Temp C	5.0000		5.0000	
Heat Duty kW		-9610.0000		-9220.0000
Calc Ht Duty kW	23034.8770	-9610.0000	19710.1934	-9220.0000
LMTD C	7.3793		17.6771	
LMTD Corr F	1.0000		1.0000	

Equip. No.	11	12	13
Name		TT-625	TT-628
Pressure drop 1 Pa	69000.0000		69000.0000
Pressure drop 2 Pa	69000.0000		
T Out Str 1 C	120.0000	120.0000	113.8000

EQUIPMENT SUMMARIES

Calc Ht Duty kW	11904.5938	574.1960	-5599.5229
LMTD C	27.8922	40.1056	
LMTD Corr F	1.0000	1.0000	

STREAM PROPERTIES

Stream No.	216	6106	6201	6202
Name				
- - Overall - -				
Mass flow kg/h	18227.	448694.	448694.	448694.
Temp C	102.	37.	76.	97.
Pres Pa	108000.	653000.	584000.	515000.
Vapor mass fraction	1.000	0.0000	0.0000	0.0000
Enth kW	-6.545E+004	-1.881E+006	-1.861E+006	-1.851E+006
Std. sp gr , wtr = 1	1.004	0.993	0.993	0.993
Std. sp gr , air = 1	0.637	0.655	0.655	0.655
Average mol wt	18.	19.	19.	19.
Actual dens kg/m3	0.645	984.965	964.020	949.163
Actual vol m3/h	28253.	456.	465.	473.
RVP Pa	6749.542	8404.393	8404.393	8404.393

STREAM PROPERTIES

Stream No.	6203	6204	6205	6206
Name				
- - Overall - -				
Mass flow kg/h	448694.	448694.	19201.	19201.
Temp C	120.	120.	94.	120.
Pres Pa	446000.	377000.	336000.	336000.
Vapor mass fraction	0.0000	0.0000	0.0000	0.0000
Enth kW	-1.839E+006	-1.839E+006	-8.157E+004	-8.100E+004
Std. sp gr , wtr = 1	0.993	0.993	0.994	0.994
Std. sp gr , air = 1	0.655	0.655	0.633	0.633
Average mol wt	19.	19.	18.	18.
Actual dens kg/m3	930.703	930.703	953.736	933.836
Actual vol m3/h	482.	482.	20.	21.
RVP Pa	8404.393	8404.393	7588.541	7588.541

59,7 a

63.85

STREAM PROPERTIES

Stream No.	6207	6208	6209	6210
Name				
- - Overall - -				
Mass flow kg/h	18227.	18227.	435442.	435442.
Temp C	99.	59.	149.	148.
Pres Pa	101000.	101000.	463100.	463100.
Vapor mass fraction	0.040469	0.0000	0.0000	0.0000
Enth kW	-7.625E+004	-7.752E+004	-1.827E+006	-1.827E+006
Std. sp gr , wtr = 1	1.004	1.004	1.005	1.005
Std. sp gr , air = 1	0.637	0.637	0.636	0.636
Average mol wt	18.	18.	18.	18.
Actual dens kg/m3	15.842	986.939	922.109	923.129
Actual vol m3/h	1151.	18.	472.	472.
RVP Pa	6749.542	6749.542	6573.398	6573.398

STREAM PROPERTIES

Stream No.	6211	6212	6213	6214
Name				
- - Overall - -				
Mass flow kg/h	435442.	32453.	9661.	449.
Temp C	114.	121.	115.	81.
Pres Pa	325100.	412000.	175000.	112000.
Vapor mass fraction	0.0000	0.0000	0.0000	1.000
Enth kW	-1.845E+006	-7.826E+004	-3.883E+004	-678.8
Std. sp gr , wtr = 1	1.005	0.856	1.011	0.804
Std. sp gr , air = 1	0.636	1.078	0.662	1.469
Average mol wt	18.	31.	19.	43.
Actual dens kg/m3	952.171	753.905	953.821	1.654
Actual vol m3/h	457.	43.	10.	271.
RVP Pa	6573.398	14737.437	7022.444	15979.849

STREAM PROPERTIES

Stream No.	6215	6216	6217	6218
Name				
- - Overall - -				
Mass flow kg/h	22344.	111721.	111721.	111721.
Temp C	79.	81.	80.	79.
Pres Pa	105000.	112000.	108500.	105000.
Vapor mass fraction	0.0000	1.000	0.31793	0.0020308
Enth kW	-3.959E+004	-1.690E+005	-1.887E+005	-1.979E+005
Std. sp gr , wtr = 1	0.804	0.804	0.804	0.804
Std. sp gr , air = 1	1.469	1.469	1.469	1.469
Average mol wt	43.	43.	43.	43.
Actual dens kg/m3	741.740	1.654	5.034	377.776
Actual vol m3/h	30.	67559.	22193.	296.
RVP Pa	15979.849	15979.907	15979.907	15979.907

STREAM PROPERTIES

Stream No.	6219	6220	6221	6222
Name				
- - Overall - -				
Mass flow kg/h	64764.	64764.	64764.	97360.
Temp C	113.	114.	113.	124.
Pres Pa	174074.	170574.	167074.	375865.
Vapor mass fraction	0.0000	0.71456	0.85212	1.000
Enth kW	-2.291E+005	-2.061E+005	-2.010E+005	-2.021E+005
Std. sp gr , wtr = 1	1.029	1.029	1.029	0.856
Std. sp gr , air = 1	0.745	0.745	0.745	1.078
Average mol wt	22.	22.	22.	31.
Actual dens kg/m3	967.120	1.701	1.365	3.693
Actual vol m3/h	67.	38077.	47435.	26366.
RVP Pa	7307.829	7307.829	7307.829	14737.434

STREAM PROPERTIES

Stream No.	6223	6224	6225	6410
Name				
- - Overall - -				
Mass flow kg/h	97360.	97360.	435442.	19201.
Temp C	118.	118.	125.	37.
Pres Pa	372365.	368865.	394100.	405000.
Vapor mass fraction	0.34938	0.015210	0.0000	0.0000
Enth kW	-2.251E+005	-2.347E+005	-1.839E+006	-8.284E+004
Std. sp gr , wtr = 1	0.856	0.856	1.005	0.994
Std. sp gr , air = 1	1.078	1.078	0.636	0.633
Average mol wt	31.	31.	18.	18.
Actual dens kg/m3	11.961	205.898	943.328	986.325
Actual vol m3/h	8140.	473.	462.	19.
RVP Pa	14737.434	14737.434	6573.398	7588.541

FLOW SUMMARIES

Stream No.	216	6106	6201	6202
Stream Name				
Temp C	102.0000	37.0000	75.9000	97.0000
Pres Pa	108000.0000	653000.0000	584000.0000	515000.0000
Enth kW	-65453.	-1.8812E+006	-1.8615E+006	-1.8507E+006
Vapor mass fraction	1.0000	0.00000	0.00000	0.00000
Total kg/h	18227.	448694.	448694.	448694.
Component mass fractions				
Water	0.9702	0.9258	0.9258	0.9258
Ethanol	0.0000	0.0472	0.0472	0.0472
Furfural	0.0298	0.0051	0.0051	0.0051
Glycerol	0.0000	0.0218	0.0218	0.0218
Acetaldehyde	0.0000	0.0001	0.0001	0.0001

Stream No.	6203	6204	6205	6206
Stream Name				
Temp C	120.0000	120.0000	94.3970	120.0000
Pres Pa	446000.0000	377000.0000	336000.0000	336000.0000
Enth kW	-1.8388E+006	-1.8388E+006	-81572.	-80998.
Vapor mass fraction	0.00000	0.00000	0.00000	0.00000
Total kg/h	448694.	448694.	19201.	19201.
Component mass fractions				
Water	0.9258	0.9258	0.9725	0.9725
Ethanol	0.0472	0.0472	0.0253	0.0253
Furfural	0.0051	0.0051	0.0022	0.0022
Glycerol	0.0218	0.0218	0.0000	0.0000
Acetaldehyde	0.0001	0.0001	0.0000	0.0000

Stream No.	6207	6208	6209	6210
Stream Name				
Temp C	99.3970	59.0694	149.0977	147.9883
Pres Pa	101000.0000	101000.0000	463099.9688	463099.9688
Enth kW	-76255.	-77525.	-1.8265E+006	-1.8271E+006
Vapor mass fraction	0.0404689	0.00000	0.00000	0.00000
Total kg/h	18227.	18227.	435442.	435442.
Component mass fractions				
Water	0.9702	0.9702	0.9736	0.9736
Ethanol	0.0000	0.0000	0.0003	0.0003
Furfural	0.0298	0.0298	0.0037	0.0037
Glycerol	0.0000	0.0000	0.0224	0.0224
Acetaldehyde	0.0000	0.0000	0.0000	0.0000

FLOW SUMMARIES

Stream No.	6211	6212	6213	6214
Stream Name				
Temp C	113.8000	121.1335	114.8301	80.8839
Pres Pa	325100.0000	412000.0000	175000.0156	112000.0000
Enth kW	-1.8446E+006	-78256.	-38834.	-678.78
Vapor mass fraction	0.00000	0.00000	0.00000	1.0000
Total kg/h	435442.	32453.	9661.	449.
Component mass fractions				
Water	0.9736	0.3127	0.9251	0.0532
Ethanol	0.0003	0.6640	0.0002	0.9454
Furfural	0.0037	0.0222	0.0746	0.0000
Glycerol	0.0224	0.0000	0.0000	0.0000
Acetaldehyde	0.0000	0.0010	0.0000	0.0014

Stream No.	6215	6216	6217	6218
Stream Name				
Temp C	79.2165	80.9000	80.0626	79.2165
Pres Pa	105000.0000	112000.0000	108500.0000	105000.0000
Enth kW	-39590.	-1.6901E+005	-1.8873E+005	-1.9795E+005
Vapor mass fraction	0.00000	1.0000	0.317932	0.00203083
Total kg/h	22344.	111721.	111721.	111721.
Component mass fractions				
Water	0.0532	0.0532	0.0532	0.0532
Ethanol	0.9454	0.9454	0.9454	0.9454
Furfural	0.0000	0.0000	0.0000	0.0000
Glycerol	0.0000	0.0000	0.0000	0.0000
Acetaldehyde	0.0014	0.0015	0.0015	0.0015

Stream No.	6219	6220	6221	6222
Stream Name				
Temp C	113.5000	113.8849	113.4127	124.3000
Pres Pa	174074.0000	170574.0000	167074.0156	375864.8750
Enth kW	-2.2910E+005	-2.0606E+005	-2.0100E+005	-2.0207E+005
Vapor mass fraction	0.00000	0.714563	0.852115	1.0000
Total kg/h	64764.	64764.	64764.	97360.
Component mass fractions				
Water	0.7961	0.7961	0.7961	0.3127
Ethanol	0.0018	0.0018	0.0018	0.6640
Furfural	0.2021	0.2021	0.2021	0.0222
Glycerol	0.0000	0.0000	0.0000	0.0000
Acetaldehyde	0.0000	0.0000	0.0000	0.0010

FLOW SUMMARIES

Stream No.	6223	6224	6225	6410
Stream Name				
Temp C	118.5000	117.5343	124.7964	37.0000
Pres Pa	372364.8438	368864.8438	394099.9688	405000.0000
Enth kW	-2.2510E+005	-2.3471E+005	-1.8390E+006	-82842.
Vapor mass fraction	0.349379	0.0152104	0.00000	0.00000
Total kg/h	97360.	97360.	435442.	19201.
Component mass fractions				
Water	0.3127	0.3127	0.9736	0.9725
Ethanol	0.6640	0.6640	0.0003	0.0253
Furfural	0.0222	0.0222	0.0037	0.0022
Glycerol	0.0000	0.0000	0.0224	0.0000
Acetaldehyde	0.0010	0.0010	0.0000	0.0000

DISTILLATION PROFILE

Unit type : SCDS Unit name: AS-601 Eqp # 1

Stg	Temp C	Pres Pa (59.9 psi)	* Net Flows * Liquid kmol/h	Vapor kmol/h	Feeds kmol/h	Product kmol/h	Duties kW (KJ/s)
1	121.1	412,000.00	2078.82			1039.41	-3.264E+004
2	124.3	419000.00	2025.08	3118.23			
3	130.6	420160.50	1995.41	3064.49			
4	136.8	421321.03	2000.02	3034.82			
5	139.4	422481.56	26628.23	3039.43	23649.85		
6	139.6	423642.09	26635.50	4017.79			
7	139.7	424802.59	26643.07	4025.06			
8	139.9	425963.12	26651.07	4032.64			
9	140.1	427123.69	26659.61	4040.64			
10	140.4	428284.22	26668.72	4049.17			
11	140.6	429444.72	26678.54	4058.29			
12	140.9	430605.25	26689.03	4068.10			
13	141.2	431765.78	26700.36	4078.59			
14	141.5	432926.31	26712.54	4089.92			
15	141.8	434086.81	26725.55	4102.10			
16	142.2	435247.34	26739.47	4115.11			
17	142.6	436407.88	26754.16	4129.02			
18	143.0	437568.41	27866.65	4143.72	1047.50		
19	143.4	438728.91	27882.72	4208.70			
20	143.8	439889.44	27899.39	4224.78			
21	144.2	441049.97	27916.34	4241.45			
22	144.6	442210.50	27933.38	4258.40			
23	145.1	443371.03	27950.22	4275.44			
24	145.5	444531.53	27966.70	4292.28			
25	145.8	445692.06	27982.53	4308.76			
26	146.2	446852.59	27997.57	4324.58			
27	146.5	448013.12	28011.76	4339.63			
28	146.8	449173.69	28024.97	4353.82			
29	147.1	450334.22	28037.23	4367.04			
30	147.4	451494.75	28048.60	4379.29			
31	147.6	452655.25	28059.14	4390.66			
32	147.8	453815.78	28068.89	4401.20			
33	148.0	454976.31	28077.99	4410.95			
34	148.2	456136.84	28086.53	4420.05			
35	148.3	457297.34	28094.63	4428.59			
36	148.5	458457.88	28102.35	4436.70			
37	148.6	459618.41	28109.84	4444.42			
38	148.8	460778.94	28117.20	4451.91			
39	148.9	461939.44	28124.33	4459.26			
40	149.1	463,099.97		4466.40		23657.93	4.76E+004

$$\frac{KJ}{sec} \times \frac{1\,Kcal}{4.1840\,KJ} \times \frac{1000\,cal}{Kcal} = \boxed{7.801 \times 10^6 \frac{cal}{sec}}$$

$$\boxed{1.138 \times 10^7 \frac{cal}{sec}}$$

Reflux ratio 2.000

TRAY PROPERTIES

Unit type : SCDS Unit name: AS-601 Eqp # 1

LIQUID

Stg	kg/h	Average mol wt	Actual vol rate m3/h	Actual density kg/m3	viscosity N-s/m2	Thermal conduct. W/m-K	Surface tension J/m2
1	64907	31.22	86.09	753.91	0.0002	0.211	0.021
2	51890	25.62	64.83	800.40	0.0002	0.294	0.027
3	41825	20.96	48.40	864.06	0.0002	0.457	0.037
4	38564	19.28	43.09	894.96	0.0002	0.568	0.044
5	509891	19.15	562.22	906.92	0.0002	0.596	0.046
6	509796	19.14	562.04	907.04	0.0002	0.597	0.046
7	509659	19.13	561.79	907.20	0.0002	0.598	0.046
8	509476	19.12	561.46	907.42	0.0002	0.599	0.046
9	509243	19.10	561.03	907.69	0.0002	0.601	0.046
10	508953	19.08	560.51	908.02	0.0002	0.602	0.046
11	508603	19.06	559.88	908.42	0.0002	0.604	0.046
12	508188	19.04	559.13	908.89	0.0002	0.606	0.046
13	507710	19.02	558.27	909.44	0.0002	0.609	0.046
14	507168	18.99	557.29	910.05	0.0002	0.612	0.046
15	506565	18.95	556.21	910.74	0.0002	0.615	0.046
16	505909	18.92	555.03	911.49	0.0002	0.618	0.047
17	505207	18.88	553.78	912.30	0.0002	0.622	0.047
18	524774	18.83	574.79	912.99	0.0002	0.626	0.047
19	524051	18.79	573.47	913.83	0.0002	0.630	0.047
20	523320	18.76	572.13	914.68	0.0002	0.633	0.047
21	522597	18.72	570.81	915.54	0.0002	0.637	0.047
22	521898	18.68	569.52	916.38	0.0002	0.641	0.048
23	521238	18.65	568.31	917.18	0.0002	0.645	0.048
24	520630	18.62	567.18	917.93	0.0002	0.648	0.048
25	520080	18.59	566.16	918.61	0.0002	0.652	0.048
26	519593	18.56	565.25	919.22	0.0002	0.655	0.048
27	519172	18.53	564.46	919.76	0.0002	0.657	0.048
28	518813	18.51	563.79	920.22	0.0002	0.660	0.048
29	518512	18.49	563.23	920.61	0.0002	0.662	0.048
30	518264	18.48	562.76	920.92	0.0002	0.663	0.049
31	518061	18.46	562.39	921.18	0.0002	0.665	0.049
32	517895	18.45	562.09	921.38	0.0002	0.666	0.049
33	517758	18.44	561.85	921.52	0.0002	0.667	0.049
34	517640	18.43	561.66	921.63	0.0002	0.668	0.049
35	517533	18.42	561.51	921.69	0.0002	0.669	0.049
36	517423	18.41	561.37	921.71	0.0002	0.670	0.049
37	517301	18.40	561.24	921.70	0.0002	0.671	0.049
38	517152	18.39	561.11	921.66	0.0002	0.672	0.049
39	516955	18.38	560.94	921.59	0.0002	0.672	0.049
40	435441	18.41	472.22	922.11	0.0002	0.673	0.049

VAPOR

Stg	kg/h	Average mol wt	Actual vol rate m3/h	Actual density kg/m3	viscosity N-s/m2	Thermal conduct. W/m-K	Compr. factor
1	0	0.00	0	0.00	0.0000	0.000	0.000
2	97360	31.22	23542	4.14	0.0000	0.026	0.957
3	84343	27.52	23572	3.58	0.0000	0.027	0.963
4	74278	24.48	23746	3.13	0.0000	0.027	0.967

TRAY PROPERTIES

5	71017	23.37	23901	2.97	0.0000	0.028	0.969
6	93651	23.31	31520	2.97	0.0000	0.028	0.969
7	93555	23.24	31505	2.97	0.0000	0.028	0.969
8	93418	23.17	31493	2.97	0.0000	0.028	0.969
9	93236	23.07	31487	2.96	0.0000	0.028	0.969
10	93002	22.97	31486	2.95	0.0000	0.028	0.969
11	92712	22.85	31493	2.94	0.0000	0.028	0.969
12	92362	22.70	31507	2.93	0.0000	0.028	0.969
13	91948	22.54	31529	2.92	0.0000	0.028	0.969
14	91469	22.36	31561	2.90	0.0000	0.028	0.969
15	90927	22.17	31601	2.88	0.0000	0.028	0.969
16	90324	21.95	31650	2.85	0.0000	0.028	0.970
17	89668	21.72	31708	2.83	0.0000	0.028	0.970
18	88967	21.47	31774	2.80	0.0000	0.028	0.970
19	89333	21.23	32225	2.77	0.0000	0.028	0.970
20	88609	20.97	32302	2.74	0.0000	0.028	0.970
21	87878	20.72	32383	2.71	0.0000	0.028	0.971
22	87155	20.47	32467	2.68	0.0000	0.029	0.971
23	86457	20.22	32550	2.66	0.0000	0.029	0.971
24	85797	19.99	32630	2.63	0.0000	0.029	0.971
25	85188	19.77	32706	2.60	0.0000	0.029	0.971
26	84638	19.57	32773	2.58	0.0000	0.029	0.971
27	84152	19.39	32833	2.56	0.0000	0.029	0.972
28	83730	19.23	32882	2.55	0.0000	0.029	0.972
29	83371	19.09	32922	2.53	0.0000	0.029	0.972
30	83070	18.97	32952	2.52	0.0000	0.029	0.972
31	82822	18.86	32972	2.51	0.0000	0.029	0.972
32	82619	18.77	32985	2.50	0.0000	0.029	0.972
33	82453	18.69	32989	2.50	0.0000	0.029	0.972
34	82316	18.62	32988	2.50	0.0000	0.029	0.972
35	82199	18.56	32981	2.49	0.0000	0.029	0.972
36	82091	18.50	32969	2.49	0.0000	0.029	0.972
37	81982	18.45	32955	2.49	0.0000	0.029	0.972
38	81860	18.39	32938	2.49	0.0000	0.029	0.972
39	81711	18.32	32920	2.48	0.0000	0.029	0.972
40	81514	18.25	32905	2.48	0.0000	0.029	0.972

TRAY COMPOSITIONS

Unit type : SCDS Unit name: AS-601 Eqp # 1

Stage # 1	121.13 C	412000.00 Pa	
	V Mass frac	L Mass frac	K
Water	0.00000	0.31273	0.00000
Ethanol	0.00000	0.66403	0.00000
Furfural	0.00000	0.02222	0.00000
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00000	0.00102	0.00000
Total kg/h	0.0000	64906.8002	

Stage # 2	124.33 C	419000.00 Pa	
	V Mass frac	L Mass frac	K
Water	0.31273	0.51956	0.73345
Ethanol	0.66403	0.45851	1.76470
Furfural	0.02222	0.02152	1.25825
Glycerol	0.00000	0.00000	0.30595
Acetaldehyde	0.00102	0.00041	3.05808
Total kg/h	97360.2003	51889.9395	

Stage # 3	130.58 C	420160.50 Pa	
	V Mass frac	L Mass frac	K
Water	0.43998	0.77437	0.74607
Ethanol	0.53759	0.21017	3.35874
Furfural	0.02179	0.01536	1.86269
Glycerol	0.00000	0.00000	0.27840
Acetaldehyde	0.00064	0.00010	8.33137
Total kg/h	84343.3325	41824.7815	

Stage # 4	136.83 C	421321.03 Pa	
	V Mass frac	L Mass frac	K
Water	0.57267	0.89522	0.81201
Ethanol	0.40847	0.09550	5.42916
Furfural	0.01836	0.00923	2.52400
Glycerol	0.00000	0.00001	0.26930
Acetaldehyde	0.00050	0.00004	15.65056
Total kg/h	74278.1745	38563.5480	

Stage # 5	139.39 C	422481.56 Pa	
	V Mass frac	L Mass frac	K
Water	0.62903	0.91091	0.84262
Ethanol	0.35531	0.06397	6.77736
Furfural	0.01517	0.00592	3.12818
Glycerol	0.00001	0.01916	0.00038
Acetaldehyde	0.00049	0.00004	13.84869
Total kg/h	71016.9446	509891.3478	

Stage # 6	139.56 C	423642.09 Pa	
	V Mass frac	L Mass frac	K
Water	0.63214	0.91164	0.84446
Ethanol	0.35231	0.06324	6.78484
Furfural	0.01531	0.00595	3.13610
Glycerol	0.00001	0.01916	0.00039
Acetaldehyde	0.00023	0.00002	13.87133
Total kg/h	93650.7786	509795.5831	

TRAY COMPOSITIONS

Stage # 7	139.74 C	424802.59 Pa	
	V Mass frac	L Mass frac	K
Water	0.63580	0.91250	0.84661
Ethanol	0.34861	0.06234	6.79447
Furfural	0.01548	0.00598	3.14544
Glycerol	0.00001	0.01916	0.00039
Acetaldehyde	0.00011	0.00001	13.90136
Total kg/h	93555.0281	509658.9384	

Stage # 8	139.93 C	425963.12 Pa	
	V Mass frac	L Mass frac	K
Water	0.64013	0.91354	0.84913
Ethanol	0.34414	0.06127	6.80677
Furfural	0.01567	0.00602	3.15645
Glycerol	0.00001	0.01917	0.00039
Acetaldehyde	0.00005	0.00000	13.94012
Total kg/h	93418.3975	509476.2541	

Stage # 9	140.13 C	427123.69 Pa	
	V Mass frac	L Mass frac	K
Water	0.64524	0.91476	0.85207
Ethanol	0.33882	0.05999	6.82218
Furfural	0.01590	0.00606	3.16929
Glycerol	0.00001	0.01918	0.00040
Acetaldehyde	0.00003	0.00000	13.98889
Total kg/h	93235.6211	509242.7674	

Stage # 10	140.36 C	428284.22 Pa	
	V Mass frac	L Mass frac	K
Water	0.65127	0.91619	0.85551
Ethanol	0.33255	0.05850	6.84117
Furfural	0.01616	0.00611	3.18410
Glycerol	0.00001	0.01919	0.00040
Acetaldehyde	0.00001	0.00000	14.04897
Total kg/h	93002.1273	508952.6384	

Stage # 11	140.60 C	429444.72 Pa	
	V Mass frac	L Mass frac	K
Water	0.65831	0.91785	0.85947
Ethanol	0.32521	0.05678	6.86411
Furfural	0.01647	0.00616	3.20091
Glycerol	0.00001	0.01920	0.00041
Acetaldehyde	0.00001	0.00000	14.12150
Total kg/h	92711.9983	508602.7486	

Stage # 12	140.87 C	430605.25 Pa	
	V Mass frac	L Mass frac	K
Water	0.66647	0.91976	0.86401
Ethanol	0.31671	0.05480	6.89144
Furfural	0.01681	0.00623	3.21969
Glycerol	0.00001	0.01922	0.00041
Acetaldehyde	0.00000	0.00000	14.20759
Total kg/h	92362.1581	508188.3352	

Stage # 13	141.16 C	431765.78 Pa

TRAY COMPOSITIONS

	V Mass frac	L Mass frac	K
Water	0.67585	0.92191	0.86915
Ethanol	0.30695	0.05256	6.92341
Furfural	0.01719	0.00629	3.24028
Glycerol	0.00001	0.01924	0.00042
Acetaldehyde	0.00000	0.00000	14.30797
Total kg/h	91947.6881	507709.8520	

Stage # 14	141.48 C	432926.31 Pa	
	V Mass frac	L Mass frac	K
Water	0.68651	0.92431	0.87489
Ethanol	0.29587	0.05007	6.96023
Furfural	0.01761	0.00636	3.26237
Glycerol	0.00001	0.01926	0.00042
Acetaldehyde	0.00000	0.00000	14.42309
Total kg/h	91469.2332	507167.9225	

Stage # 15	141.82 C	434086.81 Pa	
	V Mass frac	L Mass frac	K
Water	0.69851	0.92696	0.88124
Ethanol	0.28343	0.04734	7.00204
Furfural	0.01805	0.00643	3.28548
Glycerol	0.00001	0.01928	0.00043
Acetaldehyde	0.00000	0.00000	14.55300
Total kg/h	90927.2612	506564.8147	

Stage # 16	142.18 C	435247.34 Pa	
	V Mass frac	L Mass frac	K
Water	0.71184	0.92982	0.88815
Ethanol	0.26964	0.04438	7.04869
Furfural	0.01851	0.00649	3.30890
Glycerol	0.00001	0.01931	0.00044
Acetaldehyde	0.00000	0.00000	14.69695
Total kg/h	90324.1605	505908.7501	

Stage # 17	142.57 C	436407.88 Pa	
	V Mass frac	L Mass frac	K
Water	0.72644	0.93288	0.89554
Ethanol	0.25458	0.04124	7.09993
Furfural	0.01897	0.00655	3.33165
Glycerol	0.00001	0.01933	0.00044
Acetaldehyde	0.00000	0.00000	14.85365
Total kg/h	89668.0675	505207.3262	

Stage # 18	142.97 C	437568.41 Pa	
	V Mass frac	L Mass frac	K
Water	0.74221	0.93694	0.90316
Ethanol	0.23839	0.03793	7.16484
Furfural	0.01939	0.00651	3.39429
Glycerol	0.00001	0.01861	0.00046
Acetaldehyde	0.00000	0.00000	15.10466
Total kg/h	88966.6365	524774.2237	

Stage # 19	143.38 C	438728.91 Pa	
	V Mass frac	L Mass frac	K
Water	0.75831	0.94006	0.91099

TRAY COMPOSITIONS

Ethanol	0.22162	0.03469	7.21468
Furfural	0.02006	0.00661	3.42575
Glycerol	0.00001	0.01864	0.00047
Acetaldehyde	0.00000	0.00000	15.27143
Total kg/h	89332.5580	524050.7439	
Stage # 20	143.79 C	439889.44 Pa	
	V Mass frac	L Mass frac	K
Water	0.77529	0.94324	0.91906
Ethanol	0.20394	0.03138	7.26646
Furfural	0.02076	0.00671	3.45745
Glycerol	0.00001	0.01866	0.00048
Acetaldehyde	0.00000	0.00000	15.44503
Total kg/h	88609.0214	523319.9499	
Stage # 21	144.22 C	441049.97 Pa	
	V Mass frac	L Mass frac	K
Water	0.79287	0.94642	0.92721
Ethanol	0.18564	0.02807	7.31905
Furfural	0.02148	0.00681	3.48876
Glycerol	0.00001	0.01869	0.00049
Acetaldehyde	0.00000	0.00000	15.62184
Total kg/h	87878.2629	522596.8670	
Stage # 22	144.64 C	442210.50 Pa	
	V Mass frac	L Mass frac	K
Water	0.81071	0.94954	0.93527
Ethanol	0.16708	0.02483	7.37116
Furfural	0.02220	0.00691	3.51902
Glycerol	0.00001	0.01872	0.00050
Acetaldehyde	0.00000	0.00000	15.79797
Total kg/h	87155.1587	521898.3914	
Stage # 23	145.05 C	443371.03 Pa	
	V Mass frac	L Mass frac	K
Water	0.82846	0.95254	0.94309
Ethanol	0.14862	0.02172	7.42146
Furfural	0.02291	0.00700	3.54764
Glycerol	0.00001	0.01874	0.00051
Acetaldehyde	0.00000	0.00000	15.96946
Total kg/h	86456.6831	521238.2444	
Stage # 24	145.45 C	444531.53 Pa	
	V Mass frac	L Mass frac	K
Water	0.84575	0.95537	0.95053
Ethanol	0.13066	0.01878	7.46861
Furfural	0.02359	0.00709	3.57406
Glycerol	0.00001	0.01876	0.00052
Acetaldehyde	0.00000	0.00000	16.13260
Total kg/h	85796.5786	520629.9203	
Stage # 25	145.83 C	445692.06 Pa	
	V Mass frac	L Mass frac	K
Water	0.86225	0.95798	0.95746
Ethanol	0.11352	0.01608	7.51149
Furfural	0.02422	0.00716	3.59784

TRAY COMPOSITIONS

Glycerol	0.00001	0.01878	0.00053
Acetaldehyde	0.00000	0.00000	16.28442
Total kg/h	85188.2475	520079.8829	

Stage # 26	146.19 C	446852.59 Pa	
	V Mass frac	L Mass frac	K
Water	0.87770	0.96036	0.96381
Ethanol	0.09750	0.01362	7.54909
Furfural	0.02479	0.00723	3.61865
Glycerol	0.00001	0.01880	0.00054
Acetaldehyde	0.00000	0.00000	16.42257
Total kg/h	84638.1250	519593.2350	

Stage # 27	146.52 C	448013.12 Pa	
	V Mass frac	L Mass frac	K
Water	0.89190	0.96248	0.96953
Ethanol	0.08280	0.01143	7.58060
Furfural	0.02529	0.00728	3.63621
Glycerol	0.00001	0.01881	0.00055
Acetaldehyde	0.00000	0.00000	16.54562
Total kg/h	84151.5905	519171.7910	

Stage # 28	146.83 C	449173.69 Pa	
	V Mass frac	L Mass frac	K
Water	0.90473	0.96436	0.97460
Ethanol	0.06956	0.00950	7.60539
Furfural	0.02571	0.00732	3.65033
Glycerol	0.00001	0.01883	0.00056
Acetaldehyde	0.00000	0.00000	16.65303
Total kg/h	83730.1819	518812.5458	

Stage # 29	147.11 C	450334.22 Pa	
	V Mass frac	L Mass frac	K
Water	0.91615	0.96599	0.97903
Ethanol	0.05782	0.00783	7.62290
Furfural	0.02602	0.00734	3.66083
Glycerol	0.00001	0.01884	0.00056
Acetaldehyde	0.00000	0.00000	16.74493
Total kg/h	83370.9934	518511.6440	

Stage # 30	147.36 C	451494.75 Pa	
	V Mass frac	L Mass frac	K
Water	0.92620	0.96741	0.98286
Ethanol	0.04756	0.00640	7.63258
Furfural	0.02623	0.00734	3.66748
Glycerol	0.00001	0.01885	0.00057
Acetaldehyde	0.00000	0.00000	16.82208
Total kg/h	83070.0065	518263.5289	

Stage # 31	147.59 C	452655.25 Pa	
	V Mass frac	L Mass frac	K
Water	0.93496	0.96864	0.98614
Ethanol	0.03871	0.00518	7.63373
Furfural	0.02632	0.00733	3.66994
Glycerol	0.00001	0.01885	0.00058
Acetaldehyde	0.00000	0.00000	16.88556

TRAY COMPOSITIONS

Total kg/h	82821.9057	518060.8866	
Stage # 32	147.80 C	453815.78 Pa	
	V Mass frac	L Mass frac	K
Water	0.94256	0.96970	0.98893
Ethanol	0.03117	0.00416	7.62537
Furfural	0.02626	0.00728	3.66768
Glycerol	0.00001	0.01886	0.00058
Acetaldehyde	0.00000	0.00000	16.93677
Total kg/h	82619.2987	517894.8151	
Stage # 33	148.00 C	454976.31 Pa	
	V Mass frac	L Mass frac	K
Water	0.94916	0.97062	0.99130
Ethanol	0.02480	0.00331	7.60588
Furfural	0.02603	0.00721	3.65981
Glycerol	0.00001	0.01887	0.00059
Acetaldehyde	0.00000	0.00000	0.00000
Total kg/h	82453.2627	517757.6601	
Stage # 34	148.17 C	456136.84 Pa	
	V Mass frac	L Mass frac	K
Water	0.95492	0.97143	0.99330
Ethanol	0.01947	0.00260	7.57272
Furfural	0.02560	0.00710	3.64493
Glycerol	0.00001	0.01887	0.00059
Acetaldehyde	0.00000	0.00000	0.00000
Total kg/h	82316.1927	517640.0095	
Stage # 35	148.34 C	457297.34 Pa	
	V Mass frac	L Mass frac	K
Water	0.96004	0.97218	0.99501
Ethanol	0.01503	0.00201	7.52168
Furfural	0.02492	0.00693	3.62080
Glycerol	0.00001	0.01887	0.00060
Acetaldehyde	0.00000	0.00000	0.00000
Total kg/h	82198.5280	517532.5648	
Stage # 36	148.49 C	458457.88 Pa	
	V Mass frac	L Mass frac	K
Water	0.96471	0.97288	0.99648
Ethanol	0.01137	0.00153	7.44561
Furfural	0.02391	0.00671	3.58372
Glycerol	0.00001	0.01888	0.00060
Acetaldehyde	0.00000	0.00000	0.00000
Total kg/h	82090.9983	517423.3058	
Stage # 37	148.64 C	459618.41 Pa	
	V Mass frac	L Mass frac	K
Water	0.96915	0.97359	0.99778
Ethanol	0.00835	0.00114	7.33167
Furfural	0.02249	0.00639	3.52746
Glycerol	0.00001	0.01888	0.00061
Acetaldehyde	0.00000	0.00000	0.00000
Total kg/h	81981.8101	517301.3461	

TRAY COMPOSITIONS

Stage # 38	148.77 C	460778.94 Pa	
	V Mass frac	L Mass frac	K
Water	0.97359	0.97433	0.99896
Ethanol	0.00589	0.00082	7.15485
Furfural	0.02052	0.00596	3.44075
Glycerol	0.00001	0.01889	0.00062
Acetaldehyde	0.00000	0.00000	0.00000
Total kg/h	81859.8575	517152.2276	

Stage # 39	148.91 C	461939.44 Pa	
	V Mass frac	L Mass frac	K
Water	0.97829	0.97516	1.00008
Ethanol	0.00387	0.00056	6.86012
Furfural	0.01783	0.00538	3.30143
Glycerol	0.00001	0.01890	0.00065
Acetaldehyde	0.00000	0.00000	0.00000
Total kg/h	81710.8099	516955.4820	

Stage # 40	149.10 C	463099.97 Pa	
	V Mass frac	L Mass frac	K
Water	0.98356	0.97359	1.00172
Ethanol	0.00223	0.00025	8.83423
Furfural	0.01420	0.00373	3.77033
Glycerol	0.00001	0.02243	0.00061
Acetaldehyde	0.00000	0.00000	0.00000
Total kg/h	81514.0997	435441.4177	

SIEVE TRAY SIZING

Equip. 1 Tray No. 2

Tray Loadings	Vapor		Liquid
	84343.332 kg/h		51889.939 kg/h
	23572.361 m3/h		64.830 m3/h
Density	3.578 kg/m3		800.399 kg/m3
Tower internal diameter, m	....		2.743
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.502	2.121	0.740
Avg. weir length m	....		2.121
Weir height, m	....		0.051
Flow path length m	....		1.740
Flow path width m	....		2.546
Tray area, m2	....		5.910
Tray active area m2	....		4.430
% flood	....		74.316
Fractional entrainment	....		0.057
Aeration factor	....		0.583
Minimum (Weeping) vapor flow kg/h	....		44804.270
Tray press loss, m	....		0.106
Tray press loss, Pa	....		832.540
Downcomer clearance m	....		0.076
Downcomer backup m	....		0.187
Downcomer residence time, sec	....		7.686
Actual tray efficiency (O'Connell)	....		0.538
Actual tray efficiency (Chu)	....		0.456

Equip. 1 Tray No. 3

Tray Loadings	Vapor		Liquid
	74278.174 kg/h		41824.781 kg/h
	23746.344 m3/h		48.405 m3/h
Density	3.128 kg/m3		864.061 kg/m3
Tower internal diameter, m	....		2.438
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.444	1.883	0.582
Avg. weir length m	....		1.883
Weir height, m	....		0.051
Flow path length m	....		1.549
Flow path width m	....		2.263
Tray area, m2	....		4.670
Tray active area m2	....		3.506
% flood	....		78.865
Fractional entrainment	....		0.085
Aeration factor	....		0.575
Minimum (Weeping) vapor flow kg/h	....		33920.601
Tray press loss, m	....		0.123
Tray press loss, Pa	....		1039.969
Downcomer clearance m	....		0.076
Downcomer backup m	....		0.200

SIEVE TRAY SIZING

Downcomer residence time, sec	8.660
Actual tray efficiency (O'Connell)	0.466
Actual tray efficiency (Chu)	0.394

Equip. 1 Tray No. 4

Tray Loadings	Vapor		Liquid	
	71016.945 kg/h		38563.548 kg/h	
	23901.002 m3/h		43.090 m3/h	
Density	2.971 kg/m3		894.958 kg/m3	
Tower internal diameter, m			2.438	
Tray spacing, m			0.610	
No. of tray liquid passes			1	
Downcomer dimension,	Width m	Length m	Area m2	
Side	0.444	1.883	0.582	
Avg. weir length m			1.883	
Weir height, m			0.051	
Flow path length m			1.549	
Flow path width m			2.263	
Tray area, m2			4.670	
Tray active area m2			3.506	
% flood			73.382	
Fractional entrainment			0.071	
Aeration factor			0.576	
Minimum (Weeping) vapor flow kg/h			33301.065	
Tray press loss, m			0.116	
Tray press loss, Pa			1020.663	
Downcomer clearance m			0.076	
Downcomer backup m			0.191	
Downcomer residence time, sec			9.308	
Actual tray efficiency (O'Connell)			0.441	
Actual tray efficiency (Chu)			0.372	

Equip. 1 Tray No. 5

Tray Loadings	Vapor		Liquid	
	93650.779 kg/h		509891.348 kg/h	
	31520.470 m3/h		562.224 m3/h	
Density	2.971 kg/m3		906.919 kg/m3	
Tower internal diameter, m			3.353	
Tray spacing, m			0.610	
No. of tray liquid passes			1	
Downcomer dimension,	Width m	Length m	Area m2	
Side	0.597	2.565	1.064	
Avg. weir length m			2.565	
Weir height, m			0.051	
Flow path length m			2.159	
Flow path width m			3.104	
Tray area, m2			8.829	
Tray active area m2			6.701	
% flood			75.812	
Fractional entrainment			0.005	
Aeration factor			0.595	
Minimum (Weeping) vapor flow kg/h			80818.544	
Tray press loss, m			0.131	
Tray press loss, Pa			1166.667	

SIEVE TRAY SIZING

Downcomer clearance m	0.076
Downcomer backup m	0.396
Downcomer residence time, sec	2.700
Actual tray efficiency (O'Connell)	0.435
Actual tray efficiency (Chu)	0.734

Equip. 1 Tray No. 6

Tray Loadings	Vapor		Liquid	
	93555.028	kg/h	509795.583	kg/h
	31504.809	m3/h	562.043	m3/h
Density	2.970	kg/m3	907.039	kg/m3

Tower internal diameter, m			3.353
Tray spacing, m			0.610
No. of tray liquid passes			1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.597	2.565	1.064
Avg. weir length m			2.565
Weir height, m			0.051
Flow path length m			2.159
Flow path width m			3.104
Tray area, m2			8.829
Tray active area m2			6.701
% flood			75.755
Fractional entrainment			0.005
Aeration factor			0.595
Minimum (Weeping) vapor flow kg/h			80796.828
Tray press loss, m			0.131
Tray press loss, Pa			1166.253
Downcomer clearance m			0.076
Downcomer backup m			0.396
Downcomer residence time, sec			2.700
Actual tray efficiency (O'Connell)			0.435
Actual tray efficiency (Chu)			0.733

Equip. 1 Tray No. 7

Tray Loadings	Vapor		Liquid	
	93418.398	kg/h	509658.938	kg/h
	31493.193	m3/h	561.791	m3/h
Density	2.966	kg/m3	907.203	kg/m3

Tower internal diameter, m			3.353
Tray spacing, m			0.610
No. of tray liquid passes			1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.597	2.565	1.064
Avg. weir length m			2.565
Weir height, m			0.051
Flow path length m			2.159
Flow path width m			3.104
Tray area, m2			8.829
Tray active area m2			6.701
% flood			75.685
Fractional entrainment			0.005
Aeration factor			0.595
Minimum (Weeping) vapor flow kg/h			80752.043

SIEVE TRAY SIZING

```
   Tray press loss,    m                ................      0.131
   Tray press loss, Pa                  ................   1165.747
   Downcomer clearance    m             ................      0.076
   Downcomer backup    m                ................      0.396
   Downcomer residence time, sec        ................      2.700
   Actual tray efficiency (O'Connell)   ...........           0.435
   Actual tray efficiency (Chu)         ...........           0.733

               Equip.    1    Tray No.    8

   Tray Loadings                     Vapor                Liquid
                                  93235.621 kg/h     509476.254 kg/h
                                  31486.701 m3/h        561.457 m3/h
   Density                            2.961 kg/m3       907.417 kg/m3
   Tower internal diameter,    m  ................        3.353
   Tray spacing,    m             ................        0.610
   No. of tray liquid passes      ................            1
   Downcomer dimension,           Width  m   Length  m    Area m2
                  Side             0.597      2.565        1.064
   Avg. weir length    m          ................        2.565
   Weir height,    m              ................        0.051
   Flow path length    m          ................        2.159
   Flow path width    m           ................        3.104
   Tray area,  m2                 ................        8.829
   Tray active area  m2           ................        6.701
   % flood                        ................       75.598
   Fractional entrainment         ................        0.005
   Aeration factor                ................        0.595
   Minimum (Weeping) vapor flow  kg/h ...........     80680.305
   Tray press loss,    m          ................        0.131
   Tray press loss, Pa            ................     1165.143
   Downcomer clearance    m       ................        0.076
   Downcomer backup    m          ................        0.396
   Downcomer residence time, sec  ................        2.700
   Actual tray efficiency (O'Connell) ...........         0.434
   Actual tray efficiency (Chu)       ...........         0.732

               Equip.    1    Tray No.    9

   Tray Loadings                     Vapor                Liquid
                                  93002.127 kg/h     509242.767 kg/h
                                  31486.480 m3/h        561.033 m3/h
   Density                            2.954 kg/m3       907.687 kg/m3
   Tower internal diameter,    m  ................        3.353
   Tray spacing,    m             ................        0.610
   No. of tray liquid passes      ................            1
   Downcomer dimension,           Width  m   Length  m    Area m2
                  Side             0.597      2.565        1.064
   Avg. weir length    m          ................        2.565
   Weir height,    m              ................        0.051
   Flow path length    m          ................        2.159
   Flow path width    m           ................        3.104
   Tray area,  m2                 ................        8.829
   Tray active area  m2           ................        6.701
   % flood                        ................       75.492
   Fractional entrainment         ................        0.005
```

SIEVE TRAY SIZING

Aeration factor	....	0.595
Minimum (Weeping) vapor flow kg/h	....	80578.098
Tray press loss, m	....	0.131
Tray press loss, Pa	....	1164.438
Downcomer clearance m	....	0.076
Downcomer backup m	....	0.396
Downcomer residence time, sec	....	2.700
Actual tray efficiency (O'Connell)	....	0.434
Actual tray efficiency (Chu)	....	0.731

Equip. 1 Tray No. 10

Tray Loadings	Vapor		Liquid	
	92711.998 kg/h		508952.638 kg/h	
	31492.964 m3/h		560.508 m3/h	
Density	2.944 kg/m3		908.020 kg/m3	
Tower internal diameter, m	....		3.353	
Tray spacing, m	....		0.610	
No. of tray liquid passes	....		1	
Downcomer dimension,	Width m	Length m	Area m2	
Side	0.597	2.565	1.064	
Avg. weir length m	....		2.565	
Weir height, m	....		0.051	
Flow path length m	....		2.159	
Flow path width m	....		3.104	
Tray area, m2	....		8.829	
Tray active area m2	....		6.701	
% flood	....		75.366	
Fractional entrainment	....		0.005	
Aeration factor	....		0.595	
Minimum (Weeping) vapor flow kg/h	....		80442.218	
Tray press loss, m	....		0.131	
Tray press loss, Pa	....		1163.617	
Downcomer clearance m	....		0.076	
Downcomer backup m	....		0.395	
Downcomer residence time, sec	....		2.699	
Actual tray efficiency (O'Connell)	....		0.434	
Actual tray efficiency (Chu)	....		0.730	

Equip. 1 Tray No. 11

Tray Loadings	Vapor		Liquid	
	92362.158 kg/h		508602.749 kg/h	
	31507.296 m3/h		559.876 m3/h	
Density	2.931 kg/m3		908.420 kg/m3	
Tower internal diameter, m	....		3.353	
Tray spacing, m	....		0.610	
No. of tray liquid passes	....		1	
Downcomer dimension,	Width m	Length m	Area m2	
Side	0.597	2.565	1.064	
Avg. weir length m	....		2.565	
Weir height, m	....		0.051	
Flow path length m	....		2.159	
Flow path width m	....		3.104	
Tray area, m2	....		8.829	
Tray active area m2	....		6.701	

SIEVE TRAY SIZING

% flood	....	75.219
Fractional entrainment	....	0.005
Aeration factor	....	0.596
Minimum (Weeping) vapor flow kg/h	....	80269.825
Tray press loss, m	....	0.131
Tray press loss, Pa	....	1162.680
Downcomer clearance m	....	0.076
Downcomer backup m	....	0.395
Downcomer residence time, sec	....	2.699
Actual tray efficiency (O'Connell)	....	0.434
Actual tray efficiency (Chu)	....	0.730

Equip. 1 Tray No. 12

Tray Loadings	Vapor		Liquid
	91947.688 kg/h		508188.335 kg/h
	31529.437 m3/h		559.130 m3/h
Density	2.916 kg/m3		908.891 kg/m3
Tower internal diameter, m	....		3.353
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.597	2.565	1.064
Avg. weir length m	....		2.565
Weir height, m	....		0.051
Flow path length m	....		2.159
Flow path width m	....		3.104
Tray area, m2	....		8.829
Tray active area m2	....		6.701
% flood	....		75.049
Fractional entrainment	....		0.005
Aeration factor	....		0.596
Minimum (Weeping) vapor flow kg/h	....		80058.713
Tray press loss, m	....		0.130
Tray press loss, Pa	....		1161.610
Downcomer clearance m	....		0.076
Downcomer backup m	....		0.394
Downcomer residence time, sec	....		2.699
Actual tray efficiency (O'Connell)	....		0.434
Actual tray efficiency (Chu)	....		0.729

Equip. 1 Tray No. 13

Tray Loadings	Vapor		Liquid
	91469.233 kg/h		507709.852 kg/h
	31560.578 m3/h		558.269 m3/h
Density	2.898 kg/m3		909.436 kg/m3
Tower internal diameter, m	....		3.353
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.597	2.565	1.064
Avg. weir length m	....		2.565
Weir height, m	....		0.051
Flow path length m	....		2.159
Flow path width m	....		3.104

SIEVE TRAY SIZING

Tray area, m2	....	8.829
Tray active area m2	....	6.701
% flood	....	74.856
Fractional entrainment	....	0.004
Aeration factor	....	0.596
Minimum (Weeping) vapor flow kg/h	....	79807.650
Tray press loss, m	....	0.130
Tray press loss, Pa	....	1160.420
Downcomer clearance m	....	0.076
Downcomer backup m	....	0.393
Downcomer residence time, sec	....	2.698
Actual tray efficiency (O'Connell)	....	0.433
Actual tray efficiency (Chu)	....	0.727

Equip. 1 Tray No. 14

Tray Loadings	Vapor		Liquid
	90927.261 kg/h		507167.922 kg/h
	31600.891 m3/h		557.294 m3/h
Density	2.877 kg/m3		910.054 kg/m3
Tower internal diameter, m	....		3.353
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.597	2.565	1.064
Avg. weir length m	....		2.565
Weir height, m	....		0.051
Flow path length m	....		2.159
Flow path width m	....		3.104
Tray area, m2	....		8.829
Tray active area m2	....		6.701
% flood	....		74.641
Fractional entrainment	....		0.004
Aeration factor	....		0.596
Minimum (Weeping) vapor flow kg/h	....		79516.592
Tray press loss, m	....		0.130
Tray press loss, Pa	....		1159.112
Downcomer clearance m	....		0.076
Downcomer backup m	....		0.393
Downcomer residence time, sec	....		2.698
Actual tray efficiency (O'Connell)	....		0.433
Actual tray efficiency (Chu)	....		0.726

Equip. 1 Tray No. 15

Tray Loadings	Vapor		Liquid
	90324.160 kg/h		506564.815 kg/h
	31649.974 m3/h		556.211 m3/h
Density	2.854 kg/m3		910.742 kg/m3
Tower internal diameter, m	....		3.353
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.597	2.565	1.064
Avg. weir length m	....		2.565
Weir height, m	....		0.051

SIEVE TRAY SIZING

Flow path length m	....	2.159
Flow path width m	....	3.104
Tray area, m2	....	8.829
Tray active area m2	....	6.701
% flood	....	74.405
Fractional entrainment	....	0.004
Aeration factor	....	0.596
Minimum (Weeping) vapor flow kg/h	....	79187.086
Tray press loss, m	....	0.130
Tray press loss, Pa	....	1157.686
Downcomer clearance m	....	0.076
Downcomer backup m	....	0.392
Downcomer residence time, sec	....	2.698
Actual tray efficiency (O'Connell)	....	0.432
Actual tray efficiency (Chu)	....	0.725

Equip. 1 Tray No. 16

Tray Loadings	Vapor		Liquid
	89668.067 kg/h		505908.750 kg/h
	31708.093 m3/h		555.033 m3/h
Density	2.828 kg/m3		911.493 kg/m3
Tower internal diameter, m	....		3.353
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.597	2.565	1.064
Avg. weir length m	....		2.565
Weir height, m	....		0.051
Flow path length m	....		2.159
Flow path width m	....		3.104
Tray area, m2	....		8.829
Tray active area m2	....		6.701
% flood	....		74.150
Fractional entrainment	....		0.004
Aeration factor	....		0.596
Minimum (Weeping) vapor flow kg/h	....		78822.412
Tray press loss, m	....		0.129
Tray press loss, Pa	....		1156.170
Downcomer clearance m	....		0.076
Downcomer backup m	....		0.391
Downcomer residence time, sec	....		2.697
Actual tray efficiency (O'Connell)	....		0.432
Actual tray efficiency (Chu)	....		0.724

Equip. 1 Tray No. 17

Tray Loadings	Vapor		Liquid
	88966.636 kg/h		505207.326 kg/h
	31773.993 m3/h		553.776 m3/h
Density	2.800 kg/m3		912.296 kg/m3
Tower internal diameter, m	....		3.353
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.597	2.565	1.064

SIEVE TRAY SIZING

Avg. weir length m	....	2.565
Weir height, m	....	0.051
Flow path length m	....	2.159
Flow path width m	....	3.104
Tray area, m2	....	8.829
Tray active area m2	....	6.701
% flood	....	73.880
Fractional entrainment	....	0.004
Aeration factor	....	0.597
Minimum (Weeping) vapor flow kg/h	....	78427.524
Tray press loss, m	....	0.129
Tray press loss, Pa	....	1154.573
Downcomer clearance m	....	0.076
Downcomer backup m	....	0.390
Downcomer residence time, sec	....	2.697
Actual tray efficiency (O'Connell)	....	0.431
Actual tray efficiency (Chu)	....	0.722

Equip. 1 Tray No. 18

Tray Loadings	Vapor	Liquid
	89332.558 kg/h	524774.224 kg/h
	32224.845 m3/h	574.786 m3/h
Density	2.772 kg/m3	912.991 kg/m3
Tower internal diameter, m	....	3.353
Tray spacing, m	....	0.610
No. of tray liquid passes	....	1

Downcomer dimension,	Width m	Length m	Area m2
Side	0.597	2.565	1.064

Avg. weir length m	....	2.565
Weir height, m	....	0.051
Flow path length m	....	2.159
Flow path width m	....	3.104
Tray area, m2	....	8.829
Tray active area m2	....	6.701
% flood	....	75.332
Fractional entrainment	....	0.004
Aeration factor	....	0.596
Minimum (Weeping) vapor flow kg/h	....	78629.968
Tray press loss, m	....	0.131
Tray press loss, Pa	....	1175.368
Downcomer clearance m	....	0.076
Downcomer backup m	....	0.403
Downcomer residence time, sec	....	2.685
Actual tray efficiency (O'Connell)	....	0.431
Actual tray efficiency (Chu)	....	0.727

Equip. 1 Tray No. 19

Tray Loadings	Vapor	Liquid
	88609.021 kg/h	524050.744 kg/h
	32301.669 m3/h	573.468 m3/h
Density	2.743 kg/m3	913.827 kg/m3
Tower internal diameter, m	....	3.353
Tray spacing, m	....	0.610
No. of tray liquid passes	....	1

SIEVE TRAY SIZING

Downcomer dimension,	Width m	Length m	Area m2
Side	0.597	2.565	1.064
Avg. weir length m	....		2.565
Weir height, m	....		0.051
Flow path length m	....		2.159
Flow path width m	....		3.104
Tray area, m2	....		8.829
Tray active area m2	....		6.701
% flood	....		75.056
Fractional entrainment	....		0.004
Aeration factor	....		0.596
Minimum (Weeping) vapor flow kg/h	....		78213.606
Tray press loss, m	....		0.131
Tray press loss, Pa	....		1173.766
Downcomer clearance m	....		0.076
Downcomer backup m	....		0.402
Downcomer residence time, sec	....		2.685
Actual tray efficiency (O'Connell)	....		0.430
Actual tray efficiency (Chu)	....		0.725

Equip. 1 Tray No. 20

Tray Loadings	Vapor	Liquid
	87878.263 kg/h	523319.950 kg/h
	32383.416 m3/h	572.133 m3/h
Density	2.714 kg/m3	914.683 kg/m3
Tower internal diameter, m	....	3.353
Tray spacing, m	....	0.610
No. of tray liquid passes	....	1

Downcomer dimension,	Width m	Length m	Area m2
Side	0.597	2.565	1.064
Avg. weir length m	....		2.565
Weir height, m	....		0.051
Flow path length m	....		2.159
Flow path width m	....		3.104
Tray area, m2	....		8.829
Tray active area m2	....		6.701
% flood	....		74.778
Fractional entrainment	....		0.004
Aeration factor	....		0.596
Minimum (Weeping) vapor flow kg/h	....		77788.101
Tray press loss, m	....		0.131
Tray press loss, Pa	....		1172.179
Downcomer clearance m	....		0.076
Downcomer backup m	....		0.401
Downcomer residence time, sec	....		2.685
Actual tray efficiency (O'Connell)	....		0.430
Actual tray efficiency (Chu)	....		0.724

Equip. 1 Tray No. 21

Tray Loadings	Vapor	Liquid
	87155.159 kg/h	522596.867 kg/h
	32467.069 m3/h	570.808 m3/h
Density	2.684 kg/m3	915.539 kg/m3
Tower internal diameter, m	....	3.353

SIEVE TRAY SIZING

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 Tray spacing,    m                  ................        0.610
 No. of tray liquid passes           ................            1
 Downcomer dimension,          Width  m   Length  m      Area m2
                Side            0.597       2.565          1.064
 Avg. weir length    m           ................        2.565
 Weir height,    m               ................        0.051
 Flow path length    m           ................        2.159
 Flow path width    m            ................        3.104
 Tray area,  m2                  ................        8.829
 Tray active area  m2            ................        6.701
 % flood                         ................       74.503
 Fractional entrainment          ................        0.004
 Aeration factor                 ................        0.597
 Minimum (Weeping) vapor flow  kg/h ...........      77363.822
 Tray press loss,   m            ................        0.130
 Tray press loss, Pa             ................     1170.626
 Downcomer clearance   m         ................        0.076
 Downcomer backup   m            ................        0.400
 Downcomer residence time, sec ................          2.684
 Actual tray efficiency (O'Connell) ...........          0.430
 Actual tray efficiency (Chu)       ...........          0.722

             Equip.   1   Tray No.  22

 Tray Loadings                      Vapor                 Liquid
                              86456.683 kg/h      521898.391 kg/h
                              32550.371 m3/h         569.524 m3/h
 Density                          2.656 kg/m3        916.376 kg/m3
 Tower internal diameter,    m  ................         3.353
 Tray spacing,    m                  ................        0.610
 No. of tray liquid passes           ................            1
 Downcomer dimension,          Width  m   Length  m      Area m2
                Side            0.597       2.565          1.064
 Avg. weir length    m           ................        2.565
 Weir height,    m               ................        0.051
 Flow path length    m           ................        2.159
 Flow path width    m            ................        3.104
 Tray area,  m2                  ................        8.829
 Tray active area  m2            ................        6.701
 % flood                         ................       74.237
 Fractional entrainment          ................        0.004
 Aeration factor                 ................        0.597
 Minimum (Weeping) vapor flow  kg/h ...........      76951.138
 Tray press loss,   m            ................        0.130
 Tray press loss, Pa             ................     1169.142
 Downcomer clearance   m         ................        0.076
 Downcomer backup   m            ................        0.399
 Downcomer residence time, sec ................          2.684
 Actual tray efficiency (O'Connell) ...........          0.429
 Actual tray efficiency (Chu)       ...........          0.720

             Equip.   1   Tray No.  23

 Tray Loadings                      Vapor                 Liquid
                              85796.579 kg/h      521238.244 kg/h
                              32630.485 m3/h         568.307 m3/h
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SIEVE TRAY SIZING

Density	2.629 kg/m3		917.177 kg/m3
Tower internal diameter, m	....		3.353
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.597	2.565	1.064
Avg. weir length m	....		2.565
Weir height, m	....		0.051
Flow path length m	....		2.159
Flow path width m	....		3.104
Tray area, m2	....		8.829
Tray active area m2	....		6.701
% flood	....		73.985
Fractional entrainment	....		0.004
Aeration factor	....		0.597
Minimum (Weeping) vapor flow kg/h	....		76559.602
Tray press loss, m	....		0.130
Tray press loss, Pa	....		1167.746
Downcomer clearance m	....		0.076
Downcomer backup m	....		0.398
Downcomer residence time, sec	....		2.684
Actual tray efficiency (O'Connell)	....		0.429
Actual tray efficiency (Chu)	....		0.719

Equip. 1 Tray No. 24

Tray Loadings	Vapor		Liquid
	85188.247 kg/h		520629.920 kg/h
	32705.734 m3/h		567.181 m3/h
Density	2.605 kg/m3		917.925 kg/m3
Tower internal diameter, m	....		3.353
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.597	2.565	1.064
Avg. weir length m	....		2.565
Weir height, m	....		0.051
Flow path length m	....		2.159
Flow path width m	....		3.104
Tray area, m2	....		8.829
Tray active area m2	....		6.701
% flood	....		73.752
Fractional entrainment	....		0.004
Aeration factor	....		0.597
Minimum (Weeping) vapor flow kg/h	....		76197.288
Tray press loss, m	....		0.130
Tray press loss, Pa	....		1166.470
Downcomer clearance m	....		0.076
Downcomer backup m	....		0.397
Downcomer residence time, sec	....		2.683
Actual tray efficiency (O'Connell)	....		0.428
Actual tray efficiency (Chu)	....		0.718

Equip. 1 Tray No. 25

Tray Loadings	Vapor		Liquid

SIEVE TRAY SIZING

	84638.125 kg/h		520079.883 kg/h
	32773.469 m3/h		566.160 m3/h
Density	2.583 kg/m3		918.610 kg/m3
Tower internal diameter, m	....		3.353
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.597	2.565	1.064
Avg. weir length m	....		2.565
Weir height, m	....		0.051
Flow path length m	....		2.159
Flow path width m	....		3.104
Tray area, m2	....		8.829
Tray active area m2	....		6.701
% flood	....		73.540
Fractional entrainment	....		0.004
Aeration factor	....		0.597
Minimum (Weeping) vapor flow kg/h	....		75870.121
Tray press loss, m	....		0.129
Tray press loss, Pa	....		1165.312
Downcomer clearance m	....		0.076
Downcomer backup m	....		0.397
Downcomer residence time, sec	....		2.683
Actual tray efficiency (O'Connell)	....		0.428
Actual tray efficiency (Chu)	....		0.716

Equip. 1 Tray No. 26

Tray Loadings	Vapor		Liquid
	84151.590 kg/h		519593.235 kg/h
	32832.561 m3/h		565.253 m3/h
Density	2.563 kg/m3		919.222 kg/m3
Tower internal diameter, m	....		3.353
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.597	2.565	1.064
Avg. weir length m	....		2.565
Weir height, m	....		0.051
Flow path length m	....		2.159
Flow path width m	....		3.104
Tray area, m2	....		8.829
Tray active area m2	....		6.701
% flood	....		73.351
Fractional entrainment	....		0.004
Aeration factor	....		0.597
Minimum (Weeping) vapor flow kg/h	....		75581.792
Tray press loss, m	....		0.129
Tray press loss, Pa	....		1164.280
Downcomer clearance m	....		0.076
Downcomer backup m	....		0.396
Downcomer residence time, sec	....		2.683
Actual tray efficiency (O'Connell)	....		0.427
Actual tray efficiency (Chu)	....		0.715

Equip. 1 Tray No. 27

SIEVE TRAY SIZING

Tray Loadings	Vapor		Liquid
	83730.182 kg/h		519171.791 kg/h
	32882.296 m3/h		564.465 m3/h
Density	2.546 kg/m3		919.759 kg/m3
Tower internal diameter, m	....		3.353
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.597	2.565	1.064
Avg. weir length m	....		2.565
Weir height, m	....		0.051
Flow path length m	....		2.159
Flow path width m	....		3.104
Tray area, m2	....		8.829
Tray active area m2	....		6.701
% flood	....		73.185
Fractional entrainment	....		0.004
Aeration factor	....		0.597
Minimum (Weeping) vapor flow	kg/h		75333.797
Tray press loss, m	....		0.129
Tray press loss, Pa	....		1163.377
Downcomer clearance m	....		0.076
Downcomer backup m	....		0.395
Downcomer residence time, sec	....		2.683
Actual tray efficiency (O'Connell)	....		0.427
Actual tray efficiency (Chu)	....		0.714

Equip. 1 Tray No. 28

Tray Loadings	Vapor		Liquid
	83370.993 kg/h		518812.546 kg/h
	32921.935 m3/h		563.792 m3/h
Density	2.532 kg/m3		920.220 kg/m3
Tower internal diameter, m	....		3.353
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.597	2.565	1.064
Avg. weir length m	....		2.565
Weir height, m	....		0.051
Flow path length m	....		2.159
Flow path width m	....		3.104
Tray area, m2	....		8.829
Tray active area m2	....		6.701
% flood	....		73.041
Fractional entrainment	....		0.004
Aeration factor	....		0.598
Minimum (Weeping) vapor flow	kg/h		75125.563
Tray press loss, m	....		0.129
Tray press loss, Pa	....		1162.586
Downcomer clearance m	....		0.076
Downcomer backup m	....		0.395
Downcomer residence time, sec	....		2.682
Actual tray efficiency (O'Connell)	....		0.427
Actual tray efficiency (Chu)	....		0.713

SIEVE TRAY SIZING

Equip. 1 Tray No. 29

Tray Loadings	Vapor		Liquid
	83070.007 kg/h		518511.644 kg/h
	32951.714 m3/h		563.228 m3/h
Density	2.521 kg/m3		920.607 kg/m3
Tower internal diameter, m	....		3.200
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.578	2.462	0.989
Avg. weir length m	....		2.462
Weir height, m	....		0.051
Flow path length m	....		2.045
Flow path width m	....		2.967
Tray area, m2	....		8.045
Tray active area m2	....		6.066
% flood	....		80.253
Fractional entrainment	....		0.005
Aeration factor	....		0.591
Minimum (Weeping) vapor flow kg/h	....		68954.205
Tray press loss, m	....		0.136
Tray press loss, Pa	....		1229.465
Downcomer clearance m	....		0.076
Downcomer backup m	....		0.415
Downcomer residence time, sec	....		2.621
Actual tray efficiency (O'Connell)	....		0.427
Actual tray efficiency (Chu)	....		0.712

Equip. 1 Tray No. 30

Tray Loadings	Vapor		Liquid
	82821.906 kg/h		518263.529 kg/h
	32972.429 m3/h		562.764 m3/h
Density	2.512 kg/m3		920.925 kg/m3
Tower internal diameter, m	....		3.200
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.578	2.462	0.989
Avg. weir length m	....		2.462
Weir height, m	....		0.051
Flow path length m	....		2.045
Flow path width m	....		2.967
Tray area, m2	....		8.045
Tray active area m2	....		6.066
% flood	....		80.139
Fractional entrainment	....		0.005
Aeration factor	....		0.591
Minimum (Weeping) vapor flow kg/h	....		68828.517
Tray press loss, m	....		0.136
Tray press loss, Pa	....		1228.714
Downcomer clearance m	....		0.076
Downcomer backup m	....		0.414
Downcomer residence time, sec	....		2.620

SIEVE TRAY SIZING

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 Actual tray efficiency (O'Connell) ...........        0.427
 Actual tray efficiency (Chu)       ...........        0.711

              Equip.   1   Tray No.  31

 Tray Loadings                       Vapor                Liquid
                                 82619.299 kg/h      518060.887 kg/h
                                 32984.799 m3/h         562.389 m3/h
 Density                             2.505 kg/m3        921.180 kg/m3
 Tower internal diameter,     m ................         3.200
 Tray spacing,   m              ................         0.610
 No. of tray liquid passes      ................             1
 Downcomer dimension,           Width  m   Length  m    Area m2
               Side             0.578       2.462        0.989
 Avg. weir length    m          ................         2.462
 Weir height,   m               ................         0.051
 Flow path length    m          ................         2.045
 Flow path width    m           ................         2.967
 Tray area,  m2                 ................         8.045
 Tray active area  m2           ................         6.066
 % flood                        ................        80.043
 Fractional entrainment         ................         0.005
 Aeration factor                ................         0.591
 Minimum (Weeping) vapor flow  kg/h ...........      68730.456
 Tray press loss,    m          ................         0.136
 Tray press loss, Pa            ................      1228.057
 Downcomer clearance   m        ................         0.076
 Downcomer backup   m           ................         0.414
 Downcomer residence time, sec ................          2.620
 Actual tray efficiency (O'Connell) ...........          0.426
 Actual tray efficiency (Chu)       ...........          0.711

              Equip.   1   Tray No.  32

 Tray Loadings                       Vapor                Liquid
                                 82453.263 kg/h      517894.815 kg/h
                                 32989.418 m3/h         562.088 m3/h
 Density                             2.499 kg/m3        921.377 kg/m3
 Tower internal diameter,     m ................         3.200
 Tray spacing,   m              ................         0.610
 No. of tray liquid passes      ................             1
 Downcomer dimension,           Width  m   Length  m    Area m2
               Side             0.578       2.462        0.989
 Avg. weir length    m          ................         2.462
 Weir height,   m               ................         0.051
 Flow path length    m          ................         2.045
 Flow path width    m           ................         2.967
 Tray area,  m2                 ................         8.045
 Tray active area  m2           ................         6.066
 % flood                        ................        79.961
 Fractional entrainment         ................         0.005
 Aeration factor                ................         0.591
 Minimum (Weeping) vapor flow  kg/h ...........      68655.550
 Tray press loss,    m          ................         0.136
 Tray press loss, Pa            ................      1227.462
 Downcomer clearance   m        ................         0.076
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SIEVE TRAY SIZING

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Downcomer backup   m        ................      0.414
Downcomer residence time, sec ................    2.620
Actual tray efficiency (O'Connell) ...........    0.426
Actual tray efficiency (Chu)       ...........    0.710

            Equip.   1   Tray No.  33

Tray Loadings                       Vapor              Liquid
                                82316.193 kg/h     517757.660 kg/h
                                32987.714 m3/h        561.850 m3/h
Density                             2.495 kg/m3       921.523 kg/m3
Tower internal diameter,    m ................        3.200
Tray spacing,    m            ................        0.610
No. of tray liquid passes     ................            1
Downcomer dimension,           Width  m   Length  m   Area m2
               Side             0.578       2.462     0.989
Avg. weir length     m        ................        2.462
Weir height,    m             ................        0.051
Flow path length     m        ................        2.045
Flow path width     m         ................        2.967
Tray area,  m2                ................        8.045
Tray active area  m2          ................        6.066
% flood                       ................       79.891
Fractional entrainment        ................        0.005
Aeration factor               ................        0.591
Minimum (Weeping) vapor flow  kg/h ...........    68599.078
Tray press loss,    m         ................        0.136
Tray press loss, Pa           ................     1226.913
Downcomer clearance    m      ................        0.076
Downcomer backup   m          ................        0.413
Downcomer residence time, sec ................        2.620
Actual tray efficiency (O'Connell) ...........        0.426
Actual tray efficiency (Chu)       ...........        0.710

            Equip.   1   Tray No.  34

Tray Loadings                       Vapor              Liquid
                                82198.528 kg/h     517640.010 kg/h
                                32980.594 m3/h        561.660 m3/h
Density                             2.492 kg/m3       921.625 kg/m3
Tower internal diameter,    m ................        3.200
Tray spacing,    m            ................        0.610
No. of tray liquid passes     ................            1
Downcomer dimension,           Width  m   Length  m   Area m2
               Side             0.578       2.462     0.989
Avg. weir length     m        ................        2.462
Weir height,    m             ................        0.051
Flow path length     m        ................        2.045
Flow path width     m         ................        2.967
Tray area,  m2                ................        8.045
Tray active area  m2          ................        6.066
% flood                       ................       79.830
Fractional entrainment        ................        0.005
Aeration factor               ................        0.591
Minimum (Weeping) vapor flow  kg/h ...........    68555.951
Tray press loss,    m         ................        0.136
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SIEVE TRAY SIZING

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  Tray press loss, Pa                ................      1226.379
  Downcomer clearance    m           ................         0.076
  Downcomer backup    m              ................         0.413
  Downcomer residence time, sec ................              2.619
  Actual tray efficiency (O'Connell) ...........              0.426
  Actual tray efficiency (Chu)        ...........             0.709

               Equip.    1    Tray No.   35

  Tray Loadings                         Vapor                  Liquid
                                   82090.998 kg/h      517532.565 kg/h
                                   32969.341 m3/h         561.506 m3/h
  Density                              2.490 kg/m3        921.686 kg/m3
  Tower internal diameter,    m  ................           3.200
  Tray spacing,    m             ................           0.610
  No. of tray liquid passes      ................               1
  Downcomer dimension,           Width  m    Length  m    Area m2
                 Side             0.578       2.462        0.989
  Avg. weir length    m          ................           2.462
  Weir height,    m              ................           0.051
  Flow path length    m          ................           2.045
  Flow path width    m           ................           2.967
  Tray area,  m2                 ................           8.045
  Tray active area  m2           ................           6.066
  % flood                        ................          79.774
  Fractional entrainment         ................           0.005
  Aeration factor                ................           0.591
  Minimum (Weeping) vapor flow  kg/h ...........        68520.819
  Tray press loss,    m          ................           0.136
  Tray press loss, Pa            ................        1225.833
  Downcomer clearance    m       ................           0.076
  Downcomer backup    m          ................           0.413
  Downcomer residence time, sec ................            2.619
  Actual tray efficiency (O'Connell) ...........            0.426
  Actual tray efficiency (Chu)        ...........           0.709

               Equip.    1    Tray No.   36

  Tray Loadings                         Vapor                  Liquid
                                   81981.810 kg/h      517423.306 kg/h
                                   32954.563 m3/h         561.372 m3/h
  Density                              2.488 kg/m3        921.711 kg/m3
  Tower internal diameter,    m  ................           3.200
  Tray spacing,    m             ................           0.610
  No. of tray liquid passes      ................               1
  Downcomer dimension,           Width  m    Length  m    Area m2
                 Side             0.578       2.462        0.989
  Avg. weir length    m          ................           2.462
  Weir height,    m              ................           0.051
  Flow path length    m          ................           2.045
  Flow path width    m           ................           2.967
  Tray area,  m2                 ................           8.045
  Tray active area  m2           ................           6.066
  % flood                        ................          79.719
  Fractional entrainment         ................           0.005
  Aeration factor                ................           0.592
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SIEVE TRAY SIZING

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Minimum (Weeping) vapor flow  kg/h ...........    68487.848
Tray press loss,    m          ................        0.136
Tray press loss, Pa            ................     1225.229
Downcomer clearance    m       ................        0.076
Downcomer backup    m          ................        0.413
Downcomer residence time, sec ................        2.619
Actual tray efficiency (O'Connell) ...........        0.426
Actual tray efficiency (Chu)       ...........        0.709

             Equip.    1    Tray No.   37

Tray Loadings                     Vapor              Liquid
                              81859.858 kg/h     517301.346 kg/h
                              32937.745 m3/h        561.245 m3/h
Density                           2.485 kg/m3       921.703 kg/m3
Tower internal diameter,     m ................        3.200
Tray spacing,    m             ................        0.610
No. of tray liquid passes      ................            1
Downcomer dimension,          Width  m   Length  m    Area m2
               Side            0.578      2.462        0.989
Avg. weir length     m         ................        2.462
Weir height,    m              ................        0.051
Flow path length     m         ................        2.045
Flow path width     m          ................        2.967
Tray area,   m2                ................        8.045
Tray active area   m2          ................        6.066
% flood                        ................       79.662
Fractional entrainment         ................        0.005
Aeration factor                ................        0.592
Minimum (Weeping) vapor flow  kg/h ...........    68450.618
Tray press loss,    m          ................        0.135
Tray press loss, Pa            ................     1224.534
Downcomer clearance    m       ................        0.076
Downcomer backup    m          ................        0.413
Downcomer residence time, sec ................        2.619
Actual tray efficiency (O'Connell) ...........        0.426
Actual tray efficiency (Chu)       ...........        0.708

             Equip.    1    Tray No.   38

Tray Loadings                     Vapor              Liquid
                              81710.810 kg/h     517152.228 kg/h
                              32919.852 m3/h        561.108 m3/h
Density                           2.482 kg/m3       921.663 kg/m3
Tower internal diameter,     m ................        3.200
Tray spacing,    m             ................        0.610
No. of tray liquid passes      ................            1
Downcomer dimension,          Width  m   Length  m    Area m2
               Side            0.578      2.462        0.989
Avg. weir length     m         ................        2.462
Weir height,    m              ................        0.051
Flow path length     m         ................        2.045
Flow path width     m          ................        2.967
Tray area,   m2                ................        8.045
Tray active area   m2          ................        6.066
% flood                        ................       79.596
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SIEVE TRAY SIZING

Fractional entrainment	....	0.005
Aeration factor	....	0.592
Minimum (Weeping) vapor flow	kg/h	68401.694
Tray press loss, m	....	0.135
Tray press loss, Pa	....	1223.694
Downcomer clearance m	....	0.076
Downcomer backup m	....	0.413
Downcomer residence time, sec	....	2.618
Actual tray efficiency (O'Connell)	....	0.426
Actual tray efficiency (Chu)	....	0.708

Equip. 1 Tray No. 39

Tray Loadings	Vapor		Liquid	
	81514.100	kg/h	516955.482	kg/h
	32905.245	m3/h	560.938	m3/h
Density	2.477	kg/m3	921.590	kg/m3

Tower internal diameter, m	....	3.200
Tray spacing, m	....	0.610
No. of tray liquid passes	....	1

Downcomer dimension,	Width m	Length m	Area m2
Side	0.578	2.462	0.989

Avg. weir length m	....	2.462
Weir height, m	....	0.051
Flow path length m	....	2.045
Flow path width m	....	2.967
Tray area, m2	....	8.045
Tray active area m2	....	6.066
% flood	....	79.519
Fractional entrainment	....	0.005
Aeration factor	....	0.592
Minimum (Weeping) vapor flow	kg/h	68327.326
Tray press loss, m	....	0.135
Tray press loss, Pa	....	1222.658
Downcomer clearance m	....	0.076
Downcomer backup m	....	0.412
Downcomer residence time, sec	....	2.618
Actual tray efficiency (O'Connell)	....	0.426
Actual tray efficiency (Chu)	....	0.708

DISTILLATION PROFILE
Unit type : SCDS Unit name: AS-602 Eqp # 2

			* Net Flows	*			
Stg	Temp C	Pres Pa	Liquid kmol/h	Vapor kmol/h	Feeds kmol/h	Product kmol/h	Duties kW
1	79.2	105000.00	2100.85			525.21	-2.893E+004
2	80.9	112000.00	2110.90	2626.06		10.55	side pr
3	81.1	112926.47	2111.15	2646.66			
4	81.3	113852.94	2111.53	2646.90			
5	81.5	114779.42	2111.97	2647.29			
6	81.7	115705.89	2112.45	2647.72			
7	82.0	116632.35	2112.95	2648.20			
8	82.2	117558.82	2113.47	2648.71			
9	82.4	118485.30	2113.98	2649.22			
10	82.6	119411.77	2114.51	2649.74			
11	82.8	120338.23	2115.03	2650.27			
12	83.0	121264.70	2115.56	2650.79			
13	83.2	122191.19	2116.08	2651.31			
14	83.4	123117.66	2116.59	2651.83			
15	83.6	124044.12	2117.11	2652.35			
16	83.8	124970.59	2117.62	2652.87			
17	84.0	125897.07	2118.13	2653.38			
18	84.2	126823.54	2118.63	2653.89			
19	84.4	127750.01	2119.12	2654.39			
20	84.6	128676.47	2119.62	2654.88			
21	84.8	129602.94	2120.09	2655.38			
22	85.0	130529.42	2120.57	2655.85			
23	85.1	131455.89	2121.03	2656.33			
24	85.3	132382.36	2121.49	2656.79			
25	85.5	133308.83	2121.92	2657.24			
26	85.7	134235.30	2122.36	2657.68			
27	85.9	135161.77	2122.78	2658.11			
28	86.1	136088.23	2123.19	2658.54			
29	86.3	137014.70	2123.57	2658.94			
30	86.5	137941.19	2123.95	2659.33			
31	86.6	138867.66	2124.29	2659.71			
32	86.8	139794.12	2124.63	2660.05			
33	87.0	140720.59	2124.94	2660.39			
34	87.2	141647.08	2125.23	2660.70			
35	87.4	142573.55	2125.49	2660.98			
36	87.6	143500.00	2125.71	2661.24			
37	87.7	144426.47	2125.90	2661.47			
38	87.9	145352.94	2126.05	2661.65			
39	88.1	146279.42	2126.17	2661.81			
40	88.3	147205.89	2126.23	2661.92			
41	88.5	148132.36	2126.25	2661.99			
42	88.7	149058.83	2126.21	2662.00			
43	88.9	149985.31	2126.11	2661.97			
44	89.0	150911.78	2125.93	2661.87			
45	89.2	151838.23	2125.68	2661.68			
46	89.4	152764.70	2125.34	2661.44			
47	89.6	153691.19	2124.91	2661.10			
48	89.8	154617.66	2124.36	2660.66			
49	90.0	155544.12	2123.65	2660.12			

$6.91 \times 10^6 \frac{cal}{sec}$

DISTILLATION PROFILE

50	90.2156470.59	2122.85	2659.41			
51	90.4157397.06	2121.85	2658.60			
52	90.6158323.55	2120.64	2657.61			
53	90.8159250.02	2119.21	2656.40			
54	91.1160176.47	2117.51	2654.96			
55	91.3161102.94	2115.49	2653.27			
56	91.6162029.42	2113.06	2651.24			
57	91.8162955.89	2110.11	2648.81			
58	92.1163882.36	2106.38	2645.87			
59	92.5164808.83	2101.96	2642.13			
60	92.9165735.31	2096.51	2637.72			
61	93.3166661.78	2089.58	2632.27			
62	93.9167588.25	3037.20	2625.34	1039.41		
63	94.6168514.70	3022.58	2533.55			
64	95.7169441.19	2999.07	2518.93			
65	97.9170367.66	2964.60	2495.41			
66	103.2171294.12	2950.97	2460.94			
67	109.5172220.59	2971.47	2447.32			
68	112.5173147.06	2988.80	2467.82			
69	113.5174073.55	3000.66	2485.15			
70	114.8175000.02		2497.01		503.65	2.809E+004

6.907×10^6 cal/sec

Reflux ratio 4.000

TRAY PROPERTIES

Unit type : SCDS Unit name: AS-602 Eqp # 2

LIQUID

Stg	kg/h	Average mol wt	Actual vol rate m3/h	Actual density kg/m3	viscosity N-s/m2	Thermal conduct. W/m-K	Surface tension J/m2
1	89377	42.54	120.50	741.74	0.0004	0.162	0.019
2	89639	42.46	121.10	740.23	0.0004	0.162	0.018
3	89492	42.39	120.90	740.23	0.0004	0.162	0.018
4	89356	42.32	120.71	740.23	0.0004	0.162	0.018
5	89228	42.25	120.54	740.22	0.0004	0.162	0.018
6	89106	42.18	120.38	740.20	0.0004	0.163	0.018
7	88988	42.12	120.23	740.18	0.0004	0.163	0.018
8	88875	42.05	120.08	740.16	0.0004	0.163	0.018
9	88765	41.99	119.93	740.13	0.0004	0.163	0.018
10	88657	41.93	119.79	740.11	0.0004	0.163	0.018
11	88552	41.87	119.65	740.08	0.0004	0.163	0.018
12	88448	41.81	119.52	740.05	0.0004	0.163	0.018
13	88346	41.75	119.38	740.02	0.0004	0.163	0.018
14	88244	41.69	119.25	739.99	0.0004	0.164	0.018
15	88144	41.63	119.12	739.96	0.0004	0.164	0.018
16	88043	41.58	118.99	739.93	0.0004	0.164	0.018
17	87943	41.52	118.86	739.91	0.0004	0.164	0.018
18	87842	41.46	118.72	739.89	0.0004	0.164	0.018
19	87741	41.40	118.59	739.86	0.0004	0.164	0.018
20	87639	41.35	118.46	739.85	0.0004	0.164	0.018
21	87536	41.29	118.32	739.83	0.0004	0.164	0.018
22	87432	41.23	118.18	739.82	0.0004	0.164	0.018
23	87325	41.17	118.04	739.82	0.0004	0.165	0.018
24	87217	41.11	117.89	739.82	0.0004	0.165	0.018
25	87106	41.05	117.74	739.83	0.0004	0.165	0.018
26	86992	40.99	117.58	739.84	0.0004	0.165	0.018
27	86876	40.93	117.42	739.87	0.0004	0.165	0.019
28	86756	40.86	117.25	739.90	0.0004	0.165	0.019
29	86632	40.80	117.08	739.94	0.0004	0.165	0.019
30	86505	40.73	116.90	740.00	0.0004	0.166	0.019
31	86372	40.66	116.71	740.06	0.0004	0.166	0.019
32	86235	40.59	116.51	740.15	0.0004	0.166	0.019
33	86092	40.52	116.30	740.25	0.0004	0.166	0.019
34	85944	40.44	116.08	740.37	0.0004	0.166	0.019
35	85789	40.36	115.85	740.51	0.0004	0.167	0.019
36	85627	40.28	115.61	740.68	0.0004	0.167	0.019
37	85458	40.20	115.35	740.87	0.0004	0.167	0.019
38	85281	40.11	115.08	741.09	0.0004	0.167	0.019
39	85096	40.02	114.79	741.35	0.0004	0.168	0.019
40	84901	39.93	114.48	741.65	0.0004	0.168	0.019
41	84697	39.83	114.15	741.99	0.0004	0.168	0.019
42	84481	39.73	113.80	742.38	0.0004	0.169	0.019
43	84254	39.63	113.42	742.83	0.0004	0.169	0.019
44	84013	39.52	113.02	743.34	0.0004	0.170	0.019
45	83759	39.40	112.59	743.93	0.0004	0.170	0.019
46	83489	39.28	112.13	744.59	0.0004	0.170	0.019
47	83201	39.16	111.63	745.36	0.0004	0.171	0.019
48	82894	39.02	111.08	746.23	0.0004	0.172	0.019
49	82563	38.88	110.49	747.23	0.0004	0.172	0.019

TRAY PROPERTIES

50	82208	38.73	109.85	748.38	0.0004	0.173	0.019
51	81822	38.56	109.14	749.70	0.0004	0.174	0.019
52	81400	38.38	108.36	751.22	0.0004	0.175	0.020
53	80937	38.19	107.49	752.98	0.0004	0.176	0.020
54	80423	37.98	106.51	755.04	0.0004	0.177	0.020
55	79845	37.74	105.41	757.46	0.0003	0.179	0.020
56	79188	37.48	104.15	760.32	0.0003	0.180	0.020
57	78425	37.17	102.68	763.77	0.0003	0.183	0.021
58	77517	36.80	100.94	767.95	0.0003	0.185	0.021
59	76419	36.36	98.84	773.14	0.0003	0.188	0.021
60	75037	35.79	96.24	779.70	0.0003	0.193	0.022
61	73210	35.04	92.88	788.24	0.0003	0.199	0.023
62	100865	33.21	126.55	797.06	0.0003	0.212	0.024
63	97898	32.39	120.49	812.48	0.0003	0.224	0.025
64	92891	30.97	110.70	839.17	0.0003	0.246	0.028
65	85081	28.70	96.04	885.88	0.0003	0.295	0.034
66	77580	26.29	82.33	942.32	0.0003	0.372	0.042
67	73640	24.78	75.93	969.89	0.0003	0.432	0.047
68	69966	23.41	71.87	973.46	0.0003	0.476	0.049
69	64765	21.58	66.97	967.10	0.0003	0.532	0.051
70	9661	19.18	10.13	953.82	0.0002	0.625	0.054

VAPOR Stg	kg/h	Average mol wt	Actual vol rate m3/h	Actual density kg/m3	viscosity N-s/m2	Thermal conduct. W/m-K	Compr. factor
1	0	0.00	0	0.00	0.0000	0.000	0.000
2	111721	42.54	67556	1.65	0.0000	0.021	0.979
3	112432	42.48	67562	1.66	0.0000	0.021	0.979
4	112284	42.42	67052	1.67	0.0000	0.021	0.979
5	112149	42.36	66553	1.69	0.0000	0.021	0.979
6	112020	42.31	66063	1.70	0.0000	0.021	0.979
7	111898	42.25	65582	1.71	0.0000	0.021	0.978
8	111781	42.20	65108	1.72	0.0000	0.021	0.978
9	111668	42.15	64642	1.73	0.0000	0.021	0.978
10	111558	42.10	64183	1.74	0.0000	0.021	0.978
11	111450	42.05	63731	1.75	0.0000	0.021	0.978
12	111345	42.00	63286	1.76	0.0000	0.021	0.978
13	111241	41.96	62847	1.77	0.0000	0.021	0.978
14	111138	41.91	62415	1.78	0.0000	0.021	0.978
15	111037	41.86	61989	1.79	0.0000	0.021	0.978
16	110936	41.82	61569	1.80	0.0000	0.021	0.977
17	110836	41.77	61154	1.81	0.0000	0.021	0.977
18	110736	41.73	60746	1.82	0.0000	0.021	0.977
19	110635	41.68	60343	1.83	0.0000	0.021	0.977
20	110534	41.63	59946	1.84	0.0000	0.021	0.977
21	110432	41.59	59554	1.85	0.0000	0.021	0.977
22	110329	41.54	59168	1.86	0.0000	0.021	0.977
23	110224	41.50	58786	1.87	0.0000	0.021	0.977
24	110118	41.45	58410	1.89	0.0000	0.021	0.977
25	110010	41.40	58039	1.90	0.0000	0.021	0.977
26	109899	41.35	57672	1.91	0.0000	0.022	0.976
27	109785	41.30	57310	1.92	0.0000	0.022	0.976
28	109669	41.25	56953	1.93	0.0000	0.022	0.976
29	109549	41.20	56600	1.94	0.0000	0.022	0.976
30	109425	41.15	56252	1.95	0.0000	0.022	0.976

TRAY PROPERTIES

31	109297	41.09	55908	1.95	0.0000	0.022	0.976
32	109165	41.04	55568	1.96	0.0000	0.022	0.976
33	109028	40.98	55232	1.97	0.0000	0.022	0.976
34	108885	40.92	54900	1.98	0.0000	0.022	0.976
35	108736	40.86	54572	1.99	0.0000	0.022	0.976
36	108582	40.80	54248	2.00	0.0000	0.022	0.975
37	108420	40.74	53927	2.01	0.0000	0.022	0.975
38	108251	40.67	53610	2.02	0.0000	0.022	0.975
39	108074	40.60	53297	2.03	0.0000	0.022	0.975
40	107889	40.53	52986	2.04	0.0000	0.022	0.975
41	107694	40.46	52679	2.04	0.0000	0.022	0.975
42	107489	40.38	52375	2.05	0.0000	0.022	0.975
43	107274	40.30	52074	2.06	0.0000	0.022	0.975
44	107047	40.21	51775	2.07	0.0000	0.022	0.975
45	106806	40.13	51479	2.07	0.0000	0.022	0.975
46	106552	40.04	51186	2.08	0.0000	0.022	0.975
47	106282	39.94	50896	2.09	0.0000	0.022	0.975
48	105994	39.84	50607	2.09	0.0000	0.022	0.975
49	105687	39.73	50321	2.10	0.0000	0.022	0.975
50	105355	39.62	50035	2.11	0.0000	0.022	0.975
51	105000	39.49	49753	2.11	0.0000	0.022	0.975
52	104615	39.36	49471	2.11	0.0000	0.022	0.975
53	104193	39.22	49190	2.12	0.0000	0.022	0.975
54	103729	39.07	48910	2.12	0.0000	0.022	0.975
55	103215	38.90	48630	2.12	0.0000	0.022	0.975
56	102638	38.71	48351	2.12	0.0000	0.022	0.975
57	101980	38.50	48071	2.12	0.0000	0.022	0.975
58	101218	38.26	47789	2.12	0.0000	0.022	0.975
59	100310	37.97	47503	2.11	0.0000	0.022	0.975
60	99212	37.61	47217	2.10	0.0000	0.022	0.975
61	97829	37.17	46928	2.08	0.0000	0.022	0.975
62	96003	36.57	46636	2.06	0.0000	0.022	0.976
63	91205	36.00	44858	2.03	0.0000	0.022	0.976
64	88237	35.03	44520	1.98	0.0000	0.022	0.977
65	83231	33.35	44188	1.88	0.0000	0.022	0.978
66	75421	30.65	44062	1.71	0.0000	0.022	0.980
67	67919	27.75	44421	1.53	0.0000	0.023	0.983
68	63980	25.93	44944	1.42	0.0000	0.023	0.984
69	60306	24.27	45175	1.33	0.0000	0.024	0.984
70	55104	22.07	45345	1.22	0.0000	0.025	0.985

TRAY COMPOSITIONS

Unit type : SCDS Unit name: AS-602 Eqp # 2

Stage # 1	79.22 C	105000.00 Pa	
	V Mass frac	L Mass frac	K
Water	0.00000	0.05318	0.00000
Ethanol	0.00000	0.94537	0.00000
Furfural	0.00000	0.00000	0.00000
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00000	0.00145	0.00000
Total kg/h	0.0000	89376.5281	

Stage # 2	80.88 C	112000.00 Pa	
	V Mass frac	L Mass frac	K
Water	0.05318	0.05448	0.97798
Ethanol	0.94537	0.94463	1.00264
Furfural	0.00000	0.00000	0.66444
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00145	0.00090	1.61404
Total kg/h	111720.6654	89639.1935	

Stage # 3	81.11 C	112926.47 Pa	
	V Mass frac	L Mass frac	K
Water	0.05421	0.05571	0.97513
Ethanol	0.94478	0.94368	1.00330
Furfural	0.00000	0.00000	0.65052
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00101	0.00060	1.67535
Total kg/h	112431.9904	89491.5350	

Stage # 4	81.32 C	113852.94 Pa	
	V Mass frac	L Mass frac	K
Water	0.05520	0.05691	0.97237
Ethanol	0.94402	0.94265	1.00390
Furfural	0.00000	0.00000	0.64204
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00078	0.00045	1.74248
Total kg/h	112284.3390	89355.8116	

Stage # 5	81.54 C	114779.42 Pa	
	V Mass frac	L Mass frac	K
Water	0.05615	0.05806	0.96973
Ethanol	0.94320	0.94158	1.00445
Furfural	0.00000	0.00000	0.63672
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00065	0.00036	1.80290
Total kg/h	112148.6156	89227.5088	

Stage # 6	81.75 C	115705.89 Pa	
	V Mass frac	L Mass frac	K
Water	0.05707	0.05918	0.96720
Ethanol	0.94235	0.94050	1.00498
Furfural	0.00000	0.00000	0.63340
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00058	0.00032	1.84837
Total kg/h	112020.2986	89105.5350	

TRAY COMPOSITIONS

Stage # 7	81.96 C	116632.35 Pa	
	V Mass frac	L Mass frac	K
Water	0.05796	0.06027	0.96477
Ethanol	0.94150	0.93944	1.00549
Furfural	0.00000	0.00000	0.63140
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00055	0.00029	1.87794
Total kg/h	111898.3248	88988.4302	

Stage # 8	82.17 C	117558.82 Pa	
	V Mass frac	L Mass frac	K
Water	0.05882	0.06134	0.96244
Ethanol	0.94065	0.93838	1.00600
Furfural	0.00000	0.00000	0.63031
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00053	0.00028	1.89503
Total kg/h	111781.2200	88875.0108	

Stage # 9	82.37 C	118485.30 Pa	
	V Mass frac	L Mass frac	K
Water	0.05967	0.06239	0.96020
Ethanol	0.93981	0.93734	1.00650
Furfural	0.00000	0.00000	0.62985
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00052	0.00027	1.90383
Total kg/h	111667.7935	88764.7241	

Stage # 10	82.58 C	119411.77 Pa	
	V Mass frac	L Mass frac	K
Water	0.06050	0.06342	0.95803
Ethanol	0.93898	0.93631	1.00700
Furfural	0.00000	0.00001	0.62984
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00051	0.00027	1.90766
Total kg/h	111557.5210	88657.1376	

Stage # 11	82.78 C	120338.23 Pa	
	V Mass frac	L Mass frac	K
Water	0.06132	0.06443	0.95593
Ethanol	0.93816	0.93529	1.00749
Furfural	0.00000	0.00001	0.63018
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00051	0.00027	1.90864
Total kg/h	111449.9204	88551.7625	

Stage # 12	82.98 C	121264.70 Pa	
	V Mass frac	L Mass frac	K
Water	0.06213	0.06544	0.95389
Ethanol	0.93736	0.93429	1.00799
Furfural	0.00001	0.00001	0.63075
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00051	0.00027	1.90806
Total kg/h	111344.5523	88447.9323	

Stage # 13	83.19 C	122191.19 Pa

TRAY COMPOSITIONS

	V Mass frac	L Mass frac	K
Water	0.06292	0.06643	0.95191
Ethanol	0.93656	0.93329	1.00848
Furfural	0.00001	0.00001	0.63151
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00051	0.00027	1.90664
Total kg/h	111240.7151	88345.5055	

Stage # 14	83.39 C	123117.66 Pa	
	V Mass frac	L Mass frac	K
Water	0.06371	0.06742	0.94997
Ethanol	0.93577	0.93230	1.00898
Furfural	0.00001	0.00001	0.63241
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00051	0.00027	1.90478
Total kg/h	111138.3024	88244.0993	

Stage # 15	83.59 C	124044.12 Pa	
	V Mass frac	L Mass frac	K
Water	0.06450	0.06841	0.94806
Ethanol	0.93498	0.93131	1.00948
Furfural	0.00001	0.00002	0.63341
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00051	0.00027	1.90271
Total kg/h	111036.8891	88143.5081	

Stage # 16	83.78 C	124970.59 Pa	
	V Mass frac	L Mass frac	K
Water	0.06528	0.06939	0.94620
Ethanol	0.93420	0.93032	1.00999
Furfural	0.00002	0.00002	0.63450
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00051	0.00027	1.90055
Total kg/h	110936.2979	88042.9736	

Stage # 17	83.98 C	125897.07 Pa	
	V Mass frac	L Mass frac	K
Water	0.06606	0.07037	0.94435
Ethanol	0.93341	0.92933	1.01051
Furfural	0.00002	0.00003	0.63565
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00051	0.00027	1.89835
Total kg/h	110835.7634	87942.8431	

Stage # 18	84.18 C	126823.54 Pa	
	V Mass frac	L Mass frac	K
Water	0.06683	0.07136	0.94253
Ethanol	0.93263	0.92833	1.01103
Furfural	0.00002	0.00004	0.63686
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00051	0.00027	1.89616
Total kg/h	110735.6329	87842.2519	

Stage # 19	84.37 C	127750.01 Pa	
	V Mass frac	L Mass frac	K
Water	0.06761	0.07235	0.94073

TRAY COMPOSITIONS

Ethanol	0.93184	0.92733	1.01156
Furfural	0.00003	0.00005	0.63811
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00051	0.00027	1.89398
Total kg/h	110635.0558	87740.9378	

Stage # 20	84.57 C	128676.47 Pa	
	V Mass frac	L Mass frac	K
Water	0.06840	0.07335	0.93894
Ethanol	0.93105	0.92631	1.01210
Furfural	0.00004	0.00006	0.63940
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00052	0.00027	1.89183
Total kg/h	110533.7205	87639.4181	

Stage # 21	84.76 C	129602.94 Pa	
	V Mass frac	L Mass frac	K
Water	0.06919	0.07436	0.93716
Ethanol	0.93025	0.92529	1.01265
Furfural	0.00005	0.00007	0.64072
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00052	0.00028	1.88972
Total kg/h	110432.2150	87536.0770	

Stage # 22	84.95 C	130529.42 Pa	
	V Mass frac	L Mass frac	K
Water	0.06999	0.07539	0.93539
Ethanol	0.92944	0.92425	1.01322
Furfural	0.00006	0.00009	0.64208
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00052	0.00028	1.88764
Total kg/h	110328.8597	87431.6303	

Stage # 23	85.14 C	131455.89 Pa	
	V Mass frac	L Mass frac	K
Water	0.07079	0.07642	0.93361
Ethanol	0.92861	0.92318	1.01380
Furfural	0.00007	0.00012	0.64346
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00052	0.00028	1.88560
Total kg/h	110224.4272	87325.0503	

Stage # 24	85.33 C	132382.36 Pa	
	V Mass frac	L Mass frac	K
Water	0.07161	0.07748	0.93183
Ethanol	0.92778	0.92210	1.01440
Furfural	0.00009	0.00014	0.64487
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00052	0.00028	1.88359
Total kg/h	110117.8471	87216.7763	

Stage # 25	85.52 C	133308.83 Pa	
	V Mass frac	L Mass frac	K
Water	0.07245	0.07856	0.93004
Ethanol	0.92692	0.92099	1.01501
Furfural	0.00011	0.00018	0.64632

TRAY COMPOSITIONS

Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00052	0.00028	1.88161
Total kg/h	110009.5732	87105.7809	
Stage # 26	85.71 C	134235.30 Pa	
	V Mass frac	L Mass frac	K
Water	0.07329	0.07966	0.92824
Ethanol	0.92604	0.91984	1.01565
Furfural	0.00014	0.00022	0.64779
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00052	0.00028	1.87966
Total kg/h	109898.5636	86992.3332	
Stage # 27	85.90 C	135161.77 Pa	
	V Mass frac	L Mass frac	K
Water	0.07416	0.08079	0.92643
Ethanol	0.92514	0.91866	1.01631
Furfural	0.00017	0.00027	0.64928
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00052	0.00028	1.87773
Total kg/h	109785.1159	86875.8662	
Stage # 28	86.08 C	136088.23 Pa	
	V Mass frac	L Mass frac	K
Water	0.07505	0.08194	0.92459
Ethanol	0.92421	0.91744	1.01700
Furfural	0.00021	0.00033	0.65081
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00052	0.00028	1.87583
Total kg/h	109668.6419	86756.0966	
Stage # 29	86.27 C	137014.70 Pa	
	V Mass frac	L Mass frac	K
Water	0.07596	0.08314	0.92273
Ethanol	0.92325	0.91617	1.01772
Furfural	0.00026	0.00041	0.65237
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00052	0.00028	1.87394
Total kg/h	109548.8793	86632.2446	
Stage # 30	86.46 C	137941.19 Pa	
	V Mass frac	L Mass frac	K
Water	0.07690	0.08437	0.92085
Ethanol	0.92226	0.91485	1.01847
Furfural	0.00032	0.00050	0.65396
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00053	0.00028	1.87207
Total kg/h	109425.0202	86504.5513	
Stage # 31	86.64 C	138867.66 Pa	
	V Mass frac	L Mass frac	K
Water	0.07786	0.08564	0.91893
Ethanol	0.92122	0.91347	1.01926
Furfural	0.00039	0.00061	0.65558
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00053	0.00028	1.87021

TRAY COMPOSITIONS

Total kg/h	109297.3411	86371.8259	
Stage # 32	86.83 C	139794.12 Pa	
	V Mass frac	L Mass frac	K
Water	0.07886	0.08695	0.91698
Ethanol	0.92013	0.91202	1.02009
Furfural	0.00048	0.00074	0.65722
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00053	0.00029	1.86834
Total kg/h	109164.6228	86234.7559	
Stage # 33	87.01 C	140720.59 Pa	
	V Mass frac	L Mass frac	K
Water	0.07989	0.08832	0.91499
Ethanol	0.91900	0.91050	1.02096
Furfural	0.00058	0.00090	0.65890
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00053	0.00029	1.86646
Total kg/h	109027.5457	86092.0374	
Stage # 34	87.19 C	141647.08 Pa	
	V Mass frac	L Mass frac	K
Water	0.08096	0.08974	0.91297
Ethanol	0.91780	0.90888	1.02189
Furfural	0.00071	0.00109	0.66061
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00053	0.00029	1.86457
Total kg/h	108884.8342	85943.6418	
Stage # 35	87.38 C	142573.55 Pa	
	V Mass frac	L Mass frac	K
Water	0.08208	0.09123	0.91089
Ethanol	0.91653	0.90717	1.02286
Furfural	0.00086	0.00131	0.66234
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00053	0.00029	1.86265
Total kg/h	108736.4316	85788.9172	
Stage # 36	87.56 C	143500.00 Pa	
	V Mass frac	L Mass frac	K
Water	0.08324	0.09278	0.90876
Ethanol	0.91519	0.90535	1.02390
Furfural	0.00104	0.00158	0.66409
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00053	0.00029	1.86070
Total kg/h	108581.7211	85627.2398	
Stage # 37	87.75 C	144426.47 Pa	
	V Mass frac	L Mass frac	K
Water	0.08445	0.09440	0.90658
Ethanol	0.91376	0.90341	1.02501
Furfural	0.00125	0.00190	0.66587
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00053	0.00029	1.85869
Total kg/h	108420.0509	85458.1349	

TRAY COMPOSITIONS

Stage # 38	87.93 C	145352.94 Pa	
	V Mass frac	L Mass frac	K
Water	0.08572	0.09611	0.90434
Ethanol	0.91224	0.90132	1.02620
Furfural	0.00150	0.00228	0.66766
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00053	0.00029	1.85662
Total kg/h	108250.9318	85281.3473	

Stage # 39	88.11 C	146279.42 Pa	
	V Mass frac	L Mass frac	K
Water	0.08706	0.09790	0.90204
Ethanol	0.91061	0.89908	1.02747
Furfural	0.00180	0.00273	0.66946
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00054	0.00029	1.85447
Total kg/h	108074.1442	85095.9627	

Stage # 40	88.30 C	147205.89 Pa	
	V Mass frac	L Mass frac	K
Water	0.08846	0.09980	0.89966
Ethanol	0.90886	0.89666	1.02884
Furfural	0.00215	0.00325	0.67126
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00054	0.00029	1.85223
Total kg/h	107888.7596	84901.1306	

Stage # 41	88.48 C	148132.36 Pa	
	V Mass frac	L Mass frac	K
Water	0.08993	0.10180	0.89722
Ethanol	0.90697	0.89404	1.03031
Furfural	0.00256	0.00387	0.67306
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00054	0.00030	1.84987
Total kg/h	107693.9346	84696.5817	

Stage # 42	88.67 C	149058.83 Pa	
	V Mass frac	L Mass frac	K
Water	0.09149	0.10392	0.89469
Ethanol	0.90492	0.89119	1.03191
Furfural	0.00305	0.00459	0.67484
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00054	0.00030	1.84739
Total kg/h	107489.3928	84481.2245	

Stage # 43	88.85 C	149985.31 Pa	
	V Mass frac	L Mass frac	K
Water	0.09314	0.10617	0.89207
Ethanol	0.90271	0.88810	1.03365
Furfural	0.00361	0.00543	0.67660
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00054	0.00030	1.84476
Total kg/h	107274.0073	84254.0882	

Stage # 44	89.04 C	150911.78 Pa	
	V Mass frac	L Mass frac	K

TRAY COMPOSITIONS

Water	0.09489	0.10858	0.88935
Ethanol	0.90029	0.88471	1.03555
Furfural	0.00427	0.00641	0.67832
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00054	0.00030	1.84197
Total kg/h	107046.8638	84013.3865	
Stage # 45	89.23 C	151838.23 Pa	
	V Mass frac	L Mass frac	K
Water	0.09675	0.11114	0.88652
Ethanol	0.89766	0.88100	1.03762
Furfural	0.00504	0.00755	0.67998
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00055	0.00030	1.83901
Total kg/h	106806.1692	83759.1905	
Stage # 46	89.42 C	152764.70 Pa	
	V Mass frac	L Mass frac	K
Water	0.09874	0.11390	0.88358
Ethanol	0.89477	0.87692	1.03991
Furfural	0.00594	0.00888	0.68157
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00055	0.00030	1.83588
Total kg/h	106551.9803	83488.8140	
Stage # 47	89.61 C	153691.19 Pa	
	V Mass frac	L Mass frac	K
Water	0.10088	0.11686	0.88050
Ethanol	0.89160	0.87242	1.04244
Furfural	0.00698	0.01042	0.68308
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00055	0.00031	1.83256
Total kg/h	106281.5968	83201.2577	
Stage # 48	89.81 C	154617.66 Pa	
	V Mass frac	L Mass frac	K
Water	0.10317	0.12006	0.87726
Ethanol	0.88811	0.86743	1.04526
Furfural	0.00818	0.01220	0.68447
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00055	0.00031	1.82907
Total kg/h	105994.0263	82893.8143	
Stage # 49	90.00 C	155544.12 Pa	
	V Mass frac	L Mass frac	K
Water	0.10564	0.12354	0.87385
Ethanol	0.88424	0.86190	1.04842
Furfural	0.00957	0.01426	0.68574
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00055	0.00031	1.82543
Total kg/h	105686.5828	82562.5359	
Stage # 50	90.21 C	156470.59 Pa	
	V Mass frac	L Mass frac	K
Water	0.10832	0.12733	0.87024
Ethanol	0.87996	0.85572	1.05198

TRAY COMPOSITIONS

Furfural	0.01117	0.01664	0.68685
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00056	0.00031	1.82166
Total kg/h	105355.3044	82207.6141	
Stage # 51	90.41 C	157397.06 Pa	
	V Mass frac	L Mass frac	K
Water	0.11123	0.13149	0.86639
Ethanol	0.87518	0.84879	1.05604
Furfural	0.01303	0.01940	0.68778
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00056	0.00031	1.81785
Total kg/h	105000.3897	81821.9046	
Stage # 52	90.63 C	158323.55 Pa	
	V Mass frac	L Mass frac	K
Water	0.11443	0.13610	0.86225
Ethanol	0.86983	0.84098	1.06070
Furfural	0.01517	0.02260	0.68851
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00056	0.00032	1.81411
Total kg/h	104614.6731	81400.1771	
Stage # 53	90.85 C	159250.02 Pa	
	V Mass frac	L Mass frac	K
Water	0.11796	0.14123	0.85778
Ethanol	0.86382	0.83213	1.06612
Furfural	0.01766	0.02632	0.68900
Glycerol	0.00000	0.00000	0.00000
Acetaldehyde	0.00056	0.00032	1.81062
Total kg/h	104192.9527	80936.6908	
Stage # 54	91.08 C	160176.47 Pa	
	V Mass frac	L Mass frac	K
Water	0.12188	0.14701	0.85290
Ethanol	0.85701	0.82202	1.07250
Furfural	0.02053	0.03065	0.68923
Glycerol	0.00000	0.00000	0.31931
Acetaldehyde	0.00057	0.00032	1.80765
Total kg/h	103729.4593	80422.5792	
Stage # 55	91.32 C	161102.94 Pa	
	V Mass frac	L Mass frac	K
Water	0.12629	0.15358	0.84750
Ethanol	0.84926	0.81038	1.08013
Furfural	0.02388	0.03571	0.68918
Glycerol	0.00000	0.00000	0.31924
Acetaldehyde	0.00057	0.00033	1.80565
Total kg/h	103215.3407	79845.1562	
Stage # 56	91.57 C	162029.42 Pa	
	V Mass frac	L Mass frac	K
Water	0.13129	0.16117	0.84147
Ethanol	0.84036	0.79683	1.08945
Furfural	0.02778	0.04166	0.68885
Glycerol	0.00000	0.00000	0.31916

TRAY COMPOSITIONS

Acetaldehyde	0.00058	0.00033	1.80535
Total kg/h	102637.9176	79187.6669	
Stage # 57	91.85 C	162955.89 Pa	
	V Mass frac	L Mass frac	K
Water	0.13704	0.17008	0.83461
Ethanol	0.83003	0.78089	1.10108
Furfural	0.03235	0.04869	0.68826
Glycerol	0.00000	0.00000	0.31907
Acetaldehyde	0.00058	0.00033	1.80793
Total kg/h	101980.4355	78425.2207	
Stage # 58	92.15 C	163882.36 Pa	
	V Mass frac	L Mass frac	K
Water	0.14376	0.18078	0.82665
Ethanol	0.81793	0.76185	1.11603
Furfural	0.03773	0.05704	0.68752
Glycerol	0.00000	0.00000	0.31895
Acetaldehyde	0.00058	0.00033	1.81546
Total kg/h	101217.9963	77517.0579	
Stage # 59	92.48 C	164808.83 Pa	
	V Mass frac	L Mass frac	K
Water	0.15178	0.19395	0.81722
Ethanol	0.80355	0.73869	1.13595
Furfural	0.04408	0.06702	0.68689
Glycerol	0.00000	0.00000	0.31881
Acetaldehyde	0.00059	0.00033	1.83153
Total kg/h	100309.8193	76418.8824	
Stage # 60	92.87 C	165735.31 Pa	
	V Mass frac	L Mass frac	K
Water	0.16161	0.21079	0.80572
Ethanol	0.78618	0.70991	1.16379
Furfural	0.05162	0.07897	0.68700
Glycerol	0.00000	0.00000	0.31864
Acetaldehyde	0.00059	0.00033	1.86325
Total kg/h	99211.6509	75036.6234	
Stage # 61	93.33 C	166661.78 Pa	
	V Mass frac	L Mass frac	K
Water	0.17407	0.23337	0.79123
Ethanol	0.76477	0.67310	1.20525
Furfural	0.06057	0.09320	0.68935
Glycerol	0.00000	0.00000	0.31842
Acetaldehyde	0.00059	0.00033	1.92545
Total kg/h	97829.3920	73210.1345	
Stage # 62	93.91 C	167588.25 Pa	
	V Mass frac	L Mass frac	K
Water	0.19059	0.27891	0.75242
Ethanol	0.73775	0.63016	1.28910
Furfural	0.07107	0.09056	0.86415
Glycerol	0.00000	0.00000	0.00007
Acetaldehyde	0.00059	0.00036	1.79901
Total kg/h	96002.8960	100865.1652	

TRAY COMPOSITIONS

Stage # 63	94.58 C	168514.70 Pa	
	V Mass frac	L Mass frac	K
Water	0.21046	0.31103	0.75208
Ethanol	0.69689	0.56966	1.35968
Furfural	0.09225	0.11907	0.86108
Glycerol	0.00000	0.00000	0.00007
Acetaldehyde	0.00040	0.00023	1.91702
Total kg/h	91204.5407	97897.5230	

Stage # 64	95.69 C	169441.19 Pa	
	V Mass frac	L Mass frac	K
Water	0.24379	0.36737	0.75052
Ethanol	0.63201	0.46972	1.52170
Furfural	0.12394	0.16278	0.86112
Glycerol	0.00000	0.00000	0.00007
Acetaldehyde	0.00026	0.00013	2.24864
Total kg/h	88236.9127	92891.4791	

Stage # 65	97.91 C	170367.66 Pa	
	V Mass frac	L Mass frac	K
Water	0.30264	0.46473	0.75682
Ethanol	0.52421	0.30763	1.98039
Furfural	0.17301	0.22759	0.88346
Glycerol	0.00000	0.00000	0.00007
Acetaldehyde	0.00014	0.00005	3.40832
Total kg/h	83230.8547	85081.2422	

Stage # 66	103.19 C	171294.12 Pa	
	V Mass frac	L Mass frac	K
Water	0.40576	0.58096	0.81420
Ethanol	0.34700	0.12639	3.20066
Furfural	0.24718	0.29265	0.98463
Glycerol	0.00000	0.00000	0.00011
Acetaldehyde	0.00006	0.00001	7.15796
Total kg/h	75420.6177	77579.8237	

Stage # 67	109.55 C	172220.59 Pa	
	V Mass frac	L Mass frac	K
Water	0.53201	0.65532	0.90912
Ethanol	0.14433	0.03431	4.71058
Furfural	0.32365	0.31037	1.16777
Glycerol	0.00000	0.00000	0.00017
Acetaldehyde	0.00001	0.00000	12.23800
Total kg/h	67919.1993	73640.3811	

Stage # 68	112.48 C	173147.06 Pa	
	V Mass frac	L Mass frac	K
Water	0.61458	0.71439	0.95275
Ethanol	0.03946	0.00797	5.48082
Furfural	0.34596	0.27764	1.38004
Glycerol	0.00000	0.00000	0.00027
Acetaldehyde	0.00000	0.00000	15.31148
Total kg/h	63979.7637	69966.1340	

Stage # 69	113.53 C	174073.55 Pa

TRAY COMPOSITIONS

	V Mass frac	L Mass frac	K
Water	0.68063	0.79607	0.96127
Ethanol	0.00921	0.00177	5.84367
Furfural	0.31015	0.20215	1.72496
Glycerol	0.00000	0.00000	0.00050
Acetaldehyde	0.00000	0.00000	17.67282
Total kg/h	60305.5308	64764.6132	

Stage # 70 — 114.83 C — 175000.02 Pa

	V Mass frac	L Mass frac	K
Water	0.77345	0.92512	0.96189
Ethanol	0.00204	0.00024	9.77600
Furfural	0.22451	0.07464	3.46048
Glycerol	0.00000	0.00000	0.00017
Acetaldehyde	0.00000	0.00000	34.62910
Total kg/h	55104.0029	9660.6174	

VALVE TRAY SIZING

Equip. 2 Tray No. 2

Tray Loadings	Vapor	Liquid
	112431.990 kg/h	89639.193 kg/h
	67561.810 m3/h	121.097 m3/h
Density	1.664 kg/m3	740.225 kg/m3
System factor	....	1.000
Valve type : V-1		
Valve material : S.S.		
Valve thickness, gage	....	12.000
Deck thickness, gage	....	14.000
Tower internal diameter, m	....	3.658
Tray spacing, m	....	0.610
No. of tray liquid passes	....	1
Downcomer dimension,	Width m Length m	Area m2
Side	0.349 2.150	0.511
Avg. weir length m	....	2.150
Weir height, m	....	0.051
Flow path length m	....	2.959
Flow path width m	....	3.205
Tray area, m2	....	10.507
Tray active area m2	....	9.485
% flood	....	79.096
Hole area m2	....	1.802
Approx # of valves	....	1522
Tray press loss, m	....	0.125
Tray press loss, Pa	....	907.116
Dry press drop, m	....	0.070
Downcomer clearance m	....	0.076
Downcomer head loss m	....	0.007
Downcomer backup m	....	0.218
Downcomer residence time, sec	....	3.315
Actual tray efficiency (O'Connell)	....	0.648
Actual tray efficiency (Chu)	....	0.584

Equip. 2 Tray No. 3

Tray Loadings	Vapor	Liquid
	112284.339 kg/h	89491.535 kg/h
	67051.884 m3/h	120.897 m3/h
Density	1.675 kg/m3	740.231 kg/m3
System factor	....	1.000
Valve type : V-1		
Valve material : S.S.		
Valve thickness, gage	....	12.000
Deck thickness, gage	....	14.000
Tower internal diameter, m	....	3.658
Tray spacing, m	....	0.610
No. of tray liquid passes	....	1
Downcomer dimension,	Width m Length m	Area m2
Side	0.349 2.150	0.511
Avg. weir length m	....	2.150
Weir height, m	....	0.051
Flow path length m	....	2.959

VALVE TRAY SIZING

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  Flow path width    m           ................       3.205
  Tray area,  m2                 ................      10.507
  Tray active area  m2           ................       9.485
  % flood                        ................      78.664
  Hole area  m2                  ................       1.802
  Approx # of valves             ................        1522
  Tray press loss,    m          ................       0.124
  Tray press loss, Pa            ................     902.345
  Dry press drop,    m           ................       0.069
  Downcomer clearance    m       ................       0.076
  Downcomer head loss    m       ................       0.007
  Downcomer backup    m          ................       0.217
  Downcomer residence time, sec ................        3.309
  Actual tray efficiency (O'Connell) ...........        0.648
  Actual tray efficiency (Chu)       ...........        0.584

              Equip.   2   Tray No.   4

  Tray Loadings                       Vapor               Liquid
                                 112148.616 kg/h     89355.812 kg/h
                                  66553.126 m3/h       120.714 m3/h
  Density                             1.685 kg/m3      740.228 kg/m3
  System factor                  ................       1.000
  Valve type       :  V-1
  Valve material :  S.S.
  Valve thickness, gage          ................      12.000
  Deck  thickness, gage          ................      14.000
  Tower internal diameter,    m  ................       3.658
  Tray spacing,    m             ................       0.610
  No. of tray liquid passes      ................           1
  Downcomer dimension,       Width  m   Length   m    Area m2
                     Side     0.349      2.150        0.511
  Avg. weir length    m          ................       2.150
  Weir height,    m              ................       0.051
  Flow path length    m          ................       2.959
  Flow path width    m           ................       3.205
  Tray area,  m2                 ................      10.507
  Tray active area  m2           ................       9.485
  % flood                        ................      78.242
  Hole area  m2                  ................       1.802
  Approx # of valves             ................        1522
  Tray press loss,    m          ................       0.124
  Tray press loss, Pa            ................     897.740
  Dry press drop,    m           ................       0.069
  Downcomer clearance    m       ................       0.076
  Downcomer head loss    m       ................       0.007
  Downcomer backup    m          ................       0.217
  Downcomer residence time, sec ................        3.304
  Actual tray efficiency (O'Connell) ...........        0.648
  Actual tray efficiency (Chu)       ...........        0.583

              Equip.   2   Tray No.   5

  Tray Loadings                       Vapor               Liquid
                                 112020.299 kg/h     89227.509 kg/h
                                  66063.254 m3/h       120.542 m3/h
```

VALVE TRAY SIZING

Density	1.696 kg/m3		740.218 kg/m3
System factor	....		1.000
Valve type : V-1			
Valve material : S.S.			
Valve thickness, gage	....		12.000
Deck thickness, gage	....		14.000
Tower internal diameter, m	....		3.658
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.349	2.150	0.511
Avg. weir length m	....		2.150
Weir height, m	....		0.051
Flow path length m	....		2.959
Flow path width m	....		3.205
Tray area, m2	....		10.507
Tray active area m2	....		9.485
% flood	....		77.829
Hole area m2	....		1.802
Approx # of valves	....		1522
Tray press loss, m	....		0.123
Tray press loss, Pa	....		893.255
Dry press drop, m	....		0.068
Downcomer clearance m	....		0.076
Downcomer head loss m	....		0.007
Downcomer backup m	....		0.216
Downcomer residence time, sec	....		3.298
Actual tray efficiency (O'Connell)	....		0.647
Actual tray efficiency (Chu)	....		0.583

Equip. 2 Tray No. 6

Tray Loadings	Vapor		Liquid
	111898.325 kg/h		89105.535 kg/h
	65581.907 m3/h		120.380 m3/h
Density	1.706 kg/m3		740.202 kg/m3
System factor	....		1.000
Valve type : V-1			
Valve material : S.S.			
Valve thickness, gage	....		12.000
Deck thickness, gage	....		14.000
Tower internal diameter, m	....		3.658
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.349	2.150	0.511
Avg. weir length m	....		2.150
Weir height, m	....		0.051
Flow path length m	....		2.959
Flow path width m	....		3.205
Tray area, m2	....		10.507
Tray active area m2	....		9.485
% flood	....		77.424
Hole area m2	....		1.802
Approx # of valves	....		1522
Tray press loss, m	....		0.122

VALVE TRAY SIZING

Tray press loss, Pa	888.880
Dry press drop, m	0.068
Downcomer clearance m	0.076
Downcomer head loss m	0.007
Downcomer backup m	0.215
Downcomer residence time, sec	3.293
Actual tray efficiency (O'Connell)	0.647
Actual tray efficiency (Chu)	0.583

Equip. 2 Tray No. 7

Tray Loadings	Vapor		Liquid	
	111781.220	kg/h	88988.430	kg/h
	65108.472	m3/h	120.225	m3/h
Density	1.717	kg/m3	740.182	kg/m3

System factor	1.000
Valve type : V-1	
Valve material : S.S.	
Valve thickness, gage	12.000
Deck thickness, gage	14.000
Tower internal diameter, m	3.658
Tray spacing, m	0.610
No. of tray liquid passes	1

Downcomer dimension,	Width m	Length m	Area m2
Side	0.368	2.201	0.552

Avg. weir length m	2.201
Weir height, m	0.051
Flow path length m	2.921
Flow path width m	3.219
Tray area, m2	10.507
Tray active area m2	9.402
% flood	77.348
Hole area m2	1.786
Approx # of valves	1509
Tray press loss, m	0.123
Tray press loss, Pa	889.303
Dry press drop, m	0.068
Downcomer clearance m	0.076
Downcomer head loss m	0.007
Downcomer backup m	0.215
Downcomer residence time, sec	3.550
Actual tray efficiency (O'Connell)	0.646
Actual tray efficiency (Chu)	0.582

Equip. 2 Tray No. 8

Tray Loadings	Vapor		Liquid	
	111667.794	kg/h	88875.011	kg/h
	64642.351	m3/h	120.076	m3/h
Density	1.727	kg/m3	740.159	kg/m3

System factor	1.000
Valve type : V-1	
Valve material : S.S.	
Valve thickness, gage	12.000
Deck thickness, gage	14.000
Tower internal diameter, m	3.658

VALVE TRAY SIZING

Tray spacing, m	....	0.610
No. of tray liquid passes	....	1

Downcomer dimension,	Width m	Length m	Area m2
Side	0.368	2.201	0.552

Avg. weir length m	....	2.201
Weir height, m	....	0.051
Flow path length m	....	2.921
Flow path width m	....	3.219
Tray area, m2	....	10.507
Tray active area m2	....	9.402
% flood	....	76.983
Hole area m2	....	1.786
Approx # of valves	....	1509
Tray press loss, m	....	0.122
Tray press loss, Pa	....	885.041
Dry press drop, m	....	0.068
Downcomer clearance m	....	0.076
Downcomer head loss m	....	0.007
Downcomer backup m	....	0.214
Downcomer residence time, sec	....	3.544
Actual tray efficiency (O'Connell)	....	0.646
Actual tray efficiency (Chu)	....	0.582

Equip. 2 Tray No. 9

Tray Loadings	Vapor	Liquid
	111557.521 kg/h	88764.724 kg/h
	64183.369 m3/h	119.931 m3/h
Density	1.738 kg/m3	740.134 kg/m3
System factor	....	1.000

Valve type : V-1
Valve material : S.S.

Valve thickness, gage	....	12.000
Deck thickness, gage	....	14.000
Tower internal diameter, m	....	3.658
Tray spacing, m	....	0.610
No. of tray liquid passes	....	1

Downcomer dimension,	Width m	Length m	Area m2
Side	0.368	2.201	0.552

Avg. weir length m	....	2.201
Weir height, m	....	0.051
Flow path length m	....	2.921
Flow path width m	....	3.219
Tray area, m2	....	10.507
Tray active area m2	....	9.402
% flood	....	76.623
Hole area m2	....	1.786
Approx # of valves	....	1509
Tray press loss, m	....	0.121
Tray press loss, Pa	....	880.859
Dry press drop, m	....	0.067
Downcomer clearance m	....	0.076
Downcomer head loss m	....	0.007
Downcomer backup m	....	0.213
Downcomer residence time, sec	....	3.538
Actual tray efficiency (O'Connell)	....	0.645

VALVE TRAY SIZING

Actual tray efficiency (Chu)	....	0.582

Equip. 2 Tray No. 10

Tray Loadings	Vapor		Liquid
	111449.920 kg/h		88657.138 kg/h
	63731.337 m3/h		119.790 m3/h
Density	1.749 kg/m3		740.107 kg/m3
System factor	....		1.000
Valve type : V-1			
Valve material : S.S.			
Valve thickness, gage	....		12.000
Deck thickness, gage	....		14.000
Tower internal diameter, m	....		3.658
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.368	2.201	0.552
Avg. weir length m	....		2.201
Weir height, m	....		0.051
Flow path length m	....		2.921
Flow path width m	....		3.219
Tray area, m2	....		10.507
Tray active area m2	....		9.402
% flood	....		76.269
Hole area m2	....		1.786
Approx # of valves	....		1509
Tray press loss, m	....		0.121
Tray press loss, Pa	....		876.752
Dry press drop, m	....		0.067
Downcomer clearance m	....		0.076
Downcomer head loss m	....		0.007
Downcomer backup m	....		0.213
Downcomer residence time, sec	....		3.532
Actual tray efficiency (O'Connell)	....		0.645
Actual tray efficiency (Chu)	....		0.581

Equip. 2 Tray No. 11

Tray Loadings	Vapor		Liquid
	111344.552 kg/h		88551.762 kg/h
	63286.089 m3/h		119.652 m3/h
Density	1.759 kg/m3		740.078 kg/m3
System factor	....		1.000
Valve type : V-1			
Valve material : S.S.			
Valve thickness, gage	....		12.000
Deck thickness, gage	....		14.000
Tower internal diameter, m	....		3.658
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.368	2.201	0.552
Avg. weir length m	....		2.201
Weir height, m	....		0.051
Flow path length m	....		2.921

VALVE TRAY SIZING

Flow path width m	3.219
Tray area, m2	10.507
Tray active area m2	9.402
% flood	75.920
Hole area m2	1.786
Approx # of valves	1509
Tray press loss, m	0.120
Tray press loss, Pa	872.717
Dry press drop, m	0.066
Downcomer clearance m	0.076
Downcomer head loss m	0.007
Downcomer backup m	0.212
Downcomer residence time, sec	3.526
Actual tray efficiency (O'Connell)	0.645
Actual tray efficiency (Chu)	0.581

Equip. 2 Tray No. 12

Tray Loadings	Vapor	Liquid
	111240.715 kg/h	88447.932 kg/h
	62847.239 m3/h	119.516 m3/h
Density	1.770 kg/m3	740.049 kg/m3
System factor		1.000

Valve type : V-1
Valve material : S.S.

Valve thickness, gage			12.000
Deck thickness, gage			14.000
Tower internal diameter, m			3.658
Tray spacing, m			0.610
No. of tray liquid passes			1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.368	2.201	0.552
Avg. weir length m			2.201
Weir height, m			0.051
Flow path length m			2.921
Flow path width m			3.219
Tray area, m2			10.507
Tray active area m2			9.402
% flood			75.575
Hole area m2			1.786
Approx # of valves			1509
Tray press loss, m			0.120
Tray press loss, Pa			868.746
Dry press drop, m			0.066
Downcomer clearance m			0.076
Downcomer head loss m			0.007
Downcomer backup m			0.212
Downcomer residence time, sec			3.521
Actual tray efficiency (O'Connell)			0.644
Actual tray efficiency (Chu)			0.581

Equip. 2 Tray No. 13

Tray Loadings	Vapor	Liquid
	111138.302 kg/h	88345.506 kg/h
	62414.820 m3/h	119.383 m3/h

VALVE TRAY SIZING

Density	1.781 kg/m3	740.020 kg/m3
System factor	....	1.000
Valve type : V-1		
Valve material : S.S.		
Valve thickness, gage	....	12.000
Deck thickness, gage	....	14.000
Tower internal diameter, m	....	3.658
Tray spacing, m	....	0.610
No. of tray liquid passes	....	1

Downcomer dimension,	Width m	Length m	Area m2
Side	0.368	2.201	0.552

Avg. weir length m	....	2.201
Weir height, m	....	0.051
Flow path length m	....	2.921
Flow path width m	....	3.219
Tray area, m2	....	10.507
Tray active area m2	....	9.402
% flood	....	75.235
Hole area m2	....	1.786
Approx # of valves	....	1509
Tray press loss, m	....	0.119
Tray press loss, Pa	....	864.838
Dry press drop, m	....	0.065
Downcomer clearance m	....	0.076
Downcomer head loss m	....	0.007
Downcomer backup m	....	0.211
Downcomer residence time, sec	....	3.515
Actual tray efficiency (O'Connell)	....	0.644
Actual tray efficiency (Chu)	....	0.580

Equip. 2 Tray No. 14

Tray Loadings	Vapor	Liquid
	111036.889 kg/h	88244.099 kg/h
	61988.628 m3/h	119.250 m3/h
Density	1.791 kg/m3	739.991 kg/m3
System factor	....	1.000
Valve type : V-1		
Valve material : S.S.		
Valve thickness, gage	....	12.000
Deck thickness, gage	....	14.000
Tower internal diameter, m	....	3.658
Tray spacing, m	....	0.610
No. of tray liquid passes	....	1

Downcomer dimension,	Width m	Length m	Area m2
Side	0.368	2.201	0.552

Avg. weir length m	....	2.201
Weir height, m	....	0.051
Flow path length m	....	2.921
Flow path width m	....	3.219
Tray area, m2	....	10.507
Tray active area m2	....	9.402
% flood	....	74.899
Hole area m2	....	1.786
Approx # of valves	....	1509
Tray press loss, m	....	0.119

VALVE TRAY SIZING

Tray press loss, Pa	860.989
Dry press drop, m	0.065
Downcomer clearance m	0.076
Downcomer head loss m	0.007
Downcomer backup m	0.210
Downcomer residence time, sec	3.510
Actual tray efficiency (O'Connell)	0.644
Actual tray efficiency (Chu)	0.580

Equip. 2 Tray No. 15

Tray Loadings	Vapor	Liquid
	110936.298 kg/h	88143.508 kg/h
	61568.575 m3/h	119.119 m3/h
Density	1.802 kg/m3	739.962 kg/m3
System factor	....	1.000
Valve type : V-1		
Valve material : S.S.		
Valve thickness, gage	....	12.000
Deck thickness, gage	....	14.000
Tower internal diameter, m	....	3.658
Tray spacing, m	....	0.610
No. of tray liquid passes	....	1

Downcomer dimension,	Width m	Length m	Area m2
Side	0.368	2.201	0.552

Avg. weir length m	2.201
Weir height, m	0.051
Flow path length m	2.921
Flow path width m	3.219
Tray area, m2	10.507
Tray active area m2	9.402
% flood	74.567
Hole area m2	1.786
Approx # of valves	1509
Tray press loss, m	0.118
Tray press loss, Pa	857.198
Dry press drop, m	0.064
Downcomer clearance m	0.076
Downcomer head loss m	0.007
Downcomer backup m	0.210
Downcomer residence time, sec	3.504
Actual tray efficiency (O'Connell)	0.643
Actual tray efficiency (Chu)	0.580

Equip. 2 Tray No. 16

Tray Loadings	Vapor	Liquid
	110835.763 kg/h	88042.974 kg/h
	61154.281 m3/h	118.987 m3/h
Density	1.812 kg/m3	739.935 kg/m3
System factor	....	1.000
Valve type : V-1		
Valve material : S.S.		
Valve thickness, gage	....	12.000
Deck thickness, gage	....	14.000
Tower internal diameter, m	....	3.658

VALVE TRAY SIZING

Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.368	2.201	0.552
Avg. weir length m	....		2.201
Weir height, m	....		0.051
Flow path length m	....		2.921
Flow path width m	....		3.219
Tray area, m2	....		10.507
Tray active area m2	....		9.402
% flood	....		74.238
Hole area m2	....		1.786
Approx # of valves	....		1509
Tray press loss, m	....		0.118
Tray press loss, Pa	....		853.456
Dry press drop, m	....		0.064
Downcomer clearance m	....		0.076
Downcomer head loss m	....		0.007
Downcomer backup m	....		0.209
Downcomer residence time, sec	....		3.499
Actual tray efficiency (O'Connell)	....		0.643
Actual tray efficiency (Chu)	....		0.579

Equip. 2 Tray No. 17

Tray Loadings	Vapor		Liquid
	110735.633 kg/h		87942.843 kg/h
	60745.997 m3/h		118.856 m3/h
Density	1.823 kg/m3		739.909 kg/m3
System factor	....		1.000
Valve type : V-1			
Valve material : S.S.			
Valve thickness, gage	....		12.000
Deck thickness, gage	....		14.000
Tower internal diameter, m	....		3.505
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.349	2.100	0.500
Avg. weir length m	....		2.100
Weir height, m	....		0.051
Flow path length m	....		2.807
Flow path width m	....		3.082
Tray area, m2	....		9.650
Tray active area m2	....		8.651
% flood	....		79.911
Hole area m2	....		1.644
Approx # of valves	....		1388
Tray press loss, m	....		0.130
Tray press loss, Pa	....		940.611
Dry press drop, m	....		0.075
Downcomer clearance m	....		0.076
Downcomer head loss m	....		0.008
Downcomer backup m	....		0.223
Downcomer residence time, sec	....		3.376
Actual tray efficiency (O'Connell)	....		0.642

VALVE TRAY SIZING

Actual tray efficiency (Chu)	....	0.579

Equip. 2 Tray No. 18

Tray Loadings	Vapor		Liquid
	110635.056 kg/h		87842.252 kg/h
	60343.252 m3/h		118.724 m3/h
Density	1.833 kg/m3		739.886 kg/m3
System factor	....		1.000
Valve type : V-1			
Valve material : S.S.			
Valve thickness, gage	....		12.000
Deck thickness, gage	....		14.000
Tower internal diameter, m	....		3.505
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.349	2.100	0.500
Avg. weir length m	....		2.100
Weir height, m	....		0.051
Flow path length m	....		2.807
Flow path width m	....		3.082
Tray area, m2	....		9.650
Tray active area m2	....		8.651
% flood	....		79.562
Hole area m2	....		1.644
Approx # of valves	....		1388
Tray press loss, m	....		0.129
Tray press loss, Pa	....		936.337
Dry press drop, m	....		0.074
Downcomer clearance m	....		0.076
Downcomer head loss m	....		0.008
Downcomer backup m	....		0.222
Downcomer residence time, sec	....		3.370
Actual tray efficiency (O'Connell)	....		0.642
Actual tray efficiency (Chu)	....		0.579

Equip. 2 Tray No. 19

Tray Loadings	Vapor		Liquid
	110533.720 kg/h		87740.938 kg/h
	59945.929 m3/h		118.591 m3/h
Density	1.844 kg/m3		739.865 kg/m3
System factor	....		1.000
Valve type : V-1			
Valve material : S.S.			
Valve thickness, gage	....		12.000
Deck thickness, gage	....		14.000
Tower internal diameter, m	....		3.505
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.349	2.100	0.500
Avg. weir length m	....		2.100
Weir height, m	....		0.051
Flow path length m	....		2.807

VALVE TRAY SIZING

Flow path width m	3.082
Tray area, m2	9.650
Tray active area m2	8.651
% flood	79.217
Hole area m2	1.644
Approx # of valves	1388
Tray press loss, m	0.128
Tray press loss, Pa	932.114
Dry press drop, m	0.073
Downcomer clearance m	0.076
Downcomer head loss m	0.008
Downcomer backup m	0.222
Downcomer residence time, sec	3.364
Actual tray efficiency (O'Connell)	0.642
Actual tray efficiency (Chu)	0.578

Equip. 2 Tray No. 20

Tray Loadings	Vapor	Liquid
	110432.215 kg/h	87639.418 kg/h
	59554.399 m3/h	118.456 m3/h
Density	1.854 kg/m3	739.847 kg/m3
System factor	....	1.000

Valve type : V-1
Valve material : S.S.

Valve thickness, gage	12.000
Deck thickness, gage	14.000
Tower internal diameter, m	3.505
Tray spacing, m	0.610
No. of tray liquid passes	1

Downcomer dimension,	Width m	Length m	Area m2
Side	0.349	2.100	0.500

Avg. weir length m	2.100
Weir height, m	0.051
Flow path length m	2.807
Flow path width m	3.082
Tray area, m2	9.650
Tray active area m2	8.651
% flood	78.876
Hole area m2	1.644
Approx # of valves	1388
Tray press loss, m	0.128
Tray press loss, Pa	927.948
Dry press drop, m	0.073
Downcomer clearance m	0.076
Downcomer head loss m	0.008
Downcomer backup m	0.221
Downcomer residence time, sec	3.359
Actual tray efficiency (O'Connell)	0.641
Actual tray efficiency (Chu)	0.578

Equip. 2 Tray No. 21

Tray Loadings	Vapor	Liquid
	110328.860 kg/h	87536.077 kg/h
	59167.759 m3/h	118.319 m3/h

VALVE TRAY SIZING

Density	1.865 kg/m3	739.833 kg/m3
System factor	....	1.000
Valve type : V-1		
Valve material : S.S.		
Valve thickness, gage	....	12.000
Deck thickness, gage	....	14.000
Tower internal diameter, m	....	3.505
Tray spacing, m	....	0.610
No. of tray liquid passes	....	1

Downcomer dimension,	Width m	Length m	Area m2
Side	0.349	2.100	0.500

Avg. weir length m	....	2.100
Weir height, m	....	0.051
Flow path length m	....	2.807
Flow path width m	....	3.082
Tray area, m2	....	9.650
Tray active area m2	....	8.651
% flood	....	78.537
Hole area m2	....	1.644
Approx # of valves	....	1388
Tray press loss, m	....	0.127
Tray press loss, Pa	....	923.821
Dry press drop, m	....	0.072
Downcomer clearance m	....	0.076
Downcomer head loss m	....	0.007
Downcomer backup m	....	0.221
Downcomer residence time, sec	....	3.353
Actual tray efficiency (O'Connell)	....	0.641
Actual tray efficiency (Chu)	....	0.578

Equip. 2 Tray No. 22

Tray Loadings	Vapor	Liquid
	110224.427 kg/h	87431.630 kg/h
	58786.491 m3/h	118.179 m3/h
Density	1.875 kg/m3	739.823 kg/m3
System factor	....	1.000
Valve type : V-1		
Valve material : S.S.		
Valve thickness, gage	....	12.000
Deck thickness, gage	....	14.000
Tower internal diameter, m	....	3.505
Tray spacing, m	....	0.610
No. of tray liquid passes	....	1

Downcomer dimension,	Width m	Length m	Area m2
Side	0.349	2.100	0.500

Avg. weir length m	....	2.100
Weir height, m	....	0.051
Flow path length m	....	2.807
Flow path width m	....	3.082
Tray area, m2	....	9.650
Tray active area m2	....	8.651
% flood	....	78.202
Hole area m2	....	1.644
Approx # of valves	....	1388
Tray press loss, m	....	0.127

VALVE TRAY SIZING

Tray press loss, Pa	919.742
Dry press drop, m	0.072
Downcomer clearance m	0.076
Downcomer head loss m	0.007
Downcomer backup m	0.220
Downcomer residence time, sec	3.348
Actual tray efficiency (O'Connell)	0.641
Actual tray efficiency (Chu)	0.577

Equip. 2 Tray No. 23

Tray Loadings	Vapor	Liquid
	110117.847 kg/h	87325.050 kg/h
	58410.061 m3/h	118.036 m3/h
Density	1.885 kg/m3	739.818 kg/m3
System factor		1.000
Valve type : V-1		
Valve material : S.S.		
Valve thickness, gage		12.000
Deck thickness, gage		14.000
Tower internal diameter, m		3.505
Tray spacing, m		0.610
No. of tray liquid passes		1

Downcomer dimension,	Width m	Length m	Area m2
Side	0.349	2.100	0.500

Avg. weir length m	2.100
Weir height, m	0.051
Flow path length m	2.807
Flow path width m	3.082
Tray area, m2	9.650
Tray active area m2	8.651
% flood	77.869
Hole area m2	1.644
Approx # of valves	1388
Tray press loss, m	0.126
Tray press loss, Pa	915.699
Dry press drop, m	0.071
Downcomer clearance m	0.076
Downcomer head loss m	0.007
Downcomer backup m	0.219
Downcomer residence time, sec	3.343
Actual tray efficiency (O'Connell)	0.640
Actual tray efficiency (Chu)	0.577

Equip. 2 Tray No. 24

Tray Loadings	Vapor	Liquid
	110009.573 kg/h	87216.776 kg/h
	58038.781 m3/h	117.889 m3/h
Density	1.895 kg/m3	739.820 kg/m3
System factor		1.000
Valve type : V-1		
Valve material : S.S.		
Valve thickness, gage		12.000
Deck thickness, gage		14.000
Tower internal diameter, m		3.505

VALVE TRAY SIZING

Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.368	2.150	0.540
Avg. weir length m	....		2.150
Weir height, m	....		0.051
Flow path length m	....		2.769
Flow path width m	....		3.095
Tray area, m2	....		9.650
Tray active area m2	....		8.570
% flood	....		78.130
Hole area m2	....		1.628
Approx # of valves	....		1375
Tray press loss, m	....		0.126
Tray press loss, Pa	....		917.540
Dry press drop, m	....		0.072
Downcomer clearance m	....		0.076
Downcomer head loss m	....		0.007
Downcomer backup m	....		0.219
Downcomer residence time, sec	....		3.607
Actual tray efficiency (O'Connell)	....		0.640
Actual tray efficiency (Chu)	....		0.576

Equip. 2 Tray No. 25

Tray Loadings	Vapor		Liquid
	109898.564 kg/h		87105.781 kg/h
	57672.108 m3/h		117.738 m3/h
Density	1.906 kg/m3		739.827 kg/m3
System factor	....		1.000
Valve type : V-1			
Valve material : S.S.			
Valve thickness, gage	....		12.000
Deck thickness, gage	....		14.000
Tower internal diameter, m	....		3.505
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.368	2.150	0.540
Avg. weir length m	....		2.150
Weir height, m	....		0.051
Flow path length m	....		2.769
Flow path width m	....		3.095
Tray area, m2	....		9.650
Tray active area m2	....		8.570
% flood	....		77.799
Hole area m2	....		1.628
Approx # of valves	....		1375
Tray press loss, m	....		0.126
Tray press loss, Pa	....		913.503
Dry press drop, m	....		0.072
Downcomer clearance m	....		0.076
Downcomer head loss m	....		0.007
Downcomer backup m	....		0.218
Downcomer residence time, sec	....		3.602
Actual tray efficiency (O'Connell)	....		0.639

VALVE TRAY SIZING

Actual tray efficiency (Chu) 0.576

Equip. 2 Tray No. 26

Tray Loadings	Vapor	Liquid
	109785.116 kg/h	86992.333 kg/h
	57310.302 m3/h	117.582 m3/h
Density	1.916 kg/m3	739.842 kg/m3

```
System factor                      ................      1.000
Valve type     :  V-1
Valve material :  S.S.
Valve thickness, gage              ................     12.000
Deck  thickness, gage              ................     14.000
Tower internal diameter,     m     ................      3.505
Tray spacing,    m                 ................      0.610
No. of tray liquid passes          ................          1
Downcomer dimension,          Width  m   Length  m    Area m2
                  Side         0.368      2.150         0.540
Avg. weir length    m              ................      2.150
Weir height,    m                  ................      0.051
Flow path length    m              ................      2.769
Flow path width    m               ................      3.095
Tray area,  m2                     ................      9.650
Tray active area  m2               ................      8.570
% flood                            ................     77.470
Hole area  m2                      ................      1.628
Approx # of valves                 ................       1375
Tray press loss,    m              ................      0.125
Tray press loss, Pa                ................    909.503
Dry press drop,    m               ................      0.071
Downcomer clearance   m            ................      0.076
Downcomer head loss   m            ................      0.007
Downcomer backup   m               ................      0.218
Downcomer residence time, sec      ................      3.597
Actual tray efficiency (O'Connell) ...........           0.639
Actual tray efficiency (Chu)       ...........           0.576
```

Equip. 2 Tray No. 27

Tray Loadings	Vapor	Liquid
	109668.642 kg/h	86875.866 kg/h
	56953.120 m3/h	117.421 m3/h
Density	1.926 kg/m3	739.866 kg/m3

```
System factor                      ................      1.000
Valve type     :  V-1
Valve material :  S.S.
Valve thickness, gage              ................     12.000
Deck  thickness, gage              ................     14.000
Tower internal diameter,     m     ................      3.505
Tray spacing,    m                 ................      0.610
No. of tray liquid passes          ................          1
Downcomer dimension,          Width  m   Length  m    Area m2
                  Side         0.368      2.150         0.540
Avg. weir length    m              ................      2.150
Weir height,    m                  ................      0.051
Flow path length    m              ................      2.769
```

VALVE TRAY SIZING

Flow path width m	....	3.095
Tray area, m2	....	9.650
Tray active area m2	....	8.570
% flood	....	77.143
Hole area m2	....	1.628
Approx # of valves	....	1375
Tray press loss, m	....	0.125
Tray press loss, Pa	....	905.534
Dry press drop, m	....	0.071
Downcomer clearance m	....	0.076
Downcomer head loss m	....	0.007
Downcomer backup m	....	0.217
Downcomer residence time, sec	....	3.592
Actual tray efficiency (O'Connell)	....	0.638
Actual tray efficiency (Chu)	....	0.575

Equip. 2 Tray No. 28

Tray Loadings	Vapor		Liquid	
	109548.879	kg/h	86756.097	kg/h
	56600.482	m3/h	117.254	m3/h
Density	1.935	kg/m3	739.898	kg/m3
System factor	....		1.000	
Valve type : V-1				
Valve material : S.S.				
Valve thickness, gage	....		12.000	
Deck thickness, gage	....		14.000	
Tower internal diameter, m	....		3.505	
Tray spacing, m	....		0.610	
No. of tray liquid passes	....		1	
Downcomer dimension,	Width m	Length m	Area m2	
Side	0.368	2.150	0.540	
Avg. weir length m	....		2.150	
Weir height, m	....		0.051	
Flow path length m	....		2.769	
Flow path width m	....		3.095	
Tray area, m2	....		9.650	
Tray active area m2	....		8.570	
% flood	....		76.818	
Hole area m2	....		1.628	
Approx # of valves	....		1375	
Tray press loss, m	....		0.124	
Tray press loss, Pa	....		901.593	
Dry press drop, m	....		0.070	
Downcomer clearance m	....		0.076	
Downcomer head loss m	....		0.007	
Downcomer backup m	....		0.216	
Downcomer residence time, sec	....		3.587	
Actual tray efficiency (O'Connell)	....		0.638	
Actual tray efficiency (Chu)	....		0.575	

Equip. 2 Tray No. 29

Tray Loadings	Vapor		Liquid	
	109425.020	kg/h	86632.245	kg/h
	56252.048	m3/h	117.080	m3/h

VALVE TRAY SIZING

Density		1.945 kg/m3	739.941 kg/m3
System factor		....	1.000
Valve type : V-1			
Valve material : S.S.			
Valve thickness, gage		....	12.000
Deck thickness, gage		....	14.000
Tower internal diameter, m		....	3.505
Tray spacing, m		....	0.610
No. of tray liquid passes		....	1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.368	2.150	0.540
Avg. weir length m		....	2.150
Weir height, m		....	0.051
Flow path length m		....	2.769
Flow path width m		....	3.095
Tray area, m2		....	9.650
Tray active area m2		....	8.570
% flood		....	76.494
Hole area m2		....	1.628
Approx # of valves		....	1375
Tray press loss, m		....	0.124
Tray press loss, Pa		....	897.674
Dry press drop, m		....	0.070
Downcomer clearance m		....	0.076
Downcomer head loss m		....	0.007
Downcomer backup m		....	0.216
Downcomer residence time, sec		....	3.582
Actual tray efficiency (O'Connell)		....	0.638
Actual tray efficiency (Chu)		....	0.575

Equip. 2 Tray No. 30

Tray Loadings		Vapor	Liquid
		109297.341 kg/h	86504.551 kg/h
		55908.046 m3/h	116.899 m3/h
Density		1.955 kg/m3	739.996 kg/m3
System factor		....	1.000
Valve type : V-1			
Valve material : S.S.			
Valve thickness, gage		....	12.000
Deck thickness, gage		....	14.000
Tower internal diameter, m		....	3.505
Tray spacing, m		....	0.610
No. of tray liquid passes		....	1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.368	2.150	0.540
Avg. weir length m		....	2.150
Weir height, m		....	0.051
Flow path length m		....	2.769
Flow path width m		....	3.095
Tray area, m2		....	9.650
Tray active area m2		....	8.570
% flood		....	76.172
Hole area m2		....	1.628
Approx # of valves		....	1375
Tray press loss, m		....	0.123

VALVE TRAY SIZING

Tray press loss, Pa	893.780
Dry press drop, m	0.069
Downcomer clearance m	0.076
Downcomer head loss m	0.007
Downcomer backup m	0.215
Downcomer residence time, sec	3.578
Actual tray efficiency (O'Connell)	0.637
Actual tray efficiency (Chu)	0.574

Equip. 2 Tray No. 31

Tray Loadings	Vapor		Liquid
	109164.623 kg/h		86371.826 kg/h
	55567.982 m3/h		116.708 m3/h
Density	1.965 kg/m3		740.065 kg/m3
System factor	....		1.000
Valve type : V-1			
Valve material : S.S.			
Valve thickness, gage	....		12.000
Deck thickness, gage	....		14.000
Tower internal diameter, m	....		3.505
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.368	2.150	0.540
Avg. weir length m	....		2.150
Weir height, m	....		0.051
Flow path length m	....		2.769
Flow path width m	....		3.095
Tray area, m2	....		9.650
Tray active area m2	....		8.570
% flood	....		75.849
Hole area m2	....		1.628
Approx # of valves	....		1375
Tray press loss, m	....		0.123
Tray press loss, Pa	....		889.901
Dry press drop, m	....		0.068
Downcomer clearance m	....		0.076
Downcomer head loss m	....		0.007
Downcomer backup m	....		0.215
Downcomer residence time, sec	....		3.574
Actual tray efficiency (O'Connell)	....		0.637
Actual tray efficiency (Chu)	....		0.574

Equip. 2 Tray No. 32

Tray Loadings	Vapor	Liquid
	109027.546 kg/h	86234.756 kg/h
	55232.249 m3/h	116.510 m3/h
Density	1.974 kg/m3	740.149 kg/m3
System factor	....	1.000
Valve type : V-1		
Valve material : S.S.		
Valve thickness, gage	....	12.000
Deck thickness, gage	....	14.000
Tower internal diameter, m	....	3.505

VALVE TRAY SIZING

Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.368	2.150	0.540
Avg. weir length m	....		2.150
Weir height, m	....		0.051
Flow path length m	....		2.769
Flow path width m	....		3.095
Tray area, m2	....		9.650
Tray active area m2	....		8.570
% flood	....		75.528
Hole area m2	....		1.628
Approx # of valves	....		1375
Tray press loss, m	....		0.122
Tray press loss, Pa	....		886.044
Dry press drop, m	....		0.068
Downcomer clearance m	....		0.076
Downcomer head loss m	....		0.007
Downcomer backup m	....		0.214
Downcomer residence time, sec	....		3.570
Actual tray efficiency (O'Connell)	....		0.636
Actual tray efficiency (Chu)	....		0.573

Equip. 2 Tray No. 33

Tray Loadings	Vapor		Liquid
	108884.834 kg/h		86092.037 kg/h
	54900.356 m3/h		116.301 m3/h
Density	1.983 kg/m3		740.249 kg/m3
System factor	....		1.000
Valve type : V-1			
Valve material : S.S.			
Valve thickness, gage	....		12.000
Deck thickness, gage	....		14.000
Tower internal diameter, m	....		3.505
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.368	2.150	0.540
Avg. weir length m	....		2.150
Weir height, m	....		0.051
Flow path length m	....		2.769
Flow path width m	....		3.095
Tray area, m2	....		9.650
Tray active area m2	....		8.570
% flood	....		75.207
Hole area m2	....		1.628
Approx # of valves	....		1375
Tray press loss, m	....		0.122
Tray press loss, Pa	....		882.197
Dry press drop, m	....		0.067
Downcomer clearance m	....		0.076
Downcomer head loss m	....		0.007
Downcomer backup m	....		0.213
Downcomer residence time, sec	....		3.566
Actual tray efficiency (O'Connell)	....		0.636

VALVE TRAY SIZING

Actual tray efficiency (Chu)	....	0.573

Equip. 2 Tray No. 34

Tray Loadings	Vapor		Liquid	
	108736.432 kg/h		85943.642 kg/h	
	54572.377 m3/h		116.082 m3/h	
Density	1.993 kg/m3		740.369 kg/m3	
System factor	....		1.000	
Valve type : V-1				
Valve material : S.S.				
Valve thickness, gage	....		12.000	
Deck thickness, gage	....		14.000	
Tower internal diameter, m	....		3.505	
Tray spacing, m	....		0.610	
No. of tray liquid passes	....		1	
Downcomer dimension,	Width m	Length m	Area m2	
Side	0.368	2.150	0.540	
Avg. weir length m	....		2.150	
Weir height, m	....		0.051	
Flow path length m	....		2.769	
Flow path width m	....		3.095	
Tray area, m2	....		9.650	
Tray active area m2	....		8.570	
% flood	....		74.887	
Hole area m2	....		1.628	
Approx # of valves	....		1375	
Tray press loss, m	....		0.121	
Tray press loss, Pa	....		878.363	
Dry press drop, m	....		0.067	
Downcomer clearance m	....		0.076	
Downcomer head loss m	....		0.007	
Downcomer backup m	....		0.213	
Downcomer residence time, sec	....		3.562	
Actual tray efficiency (O'Connell)	....		0.635	
Actual tray efficiency (Chu)	....		0.572	

Equip. 2 Tray No. 35

Tray Loadings	Vapor		Liquid	
	108581.721 kg/h		85788.917 kg/h	
	54248.150 m3/h		115.851 m3/h	
Density	2.002 kg/m3		740.510 kg/m3	
System factor	....		1.000	
Valve type : V-1				
Valve material : S.S.				
Valve thickness, gage	....		12.000	
Deck thickness, gage	....		14.000	
Tower internal diameter, m	....		3.505	
Tray spacing, m	....		0.610	
No. of tray liquid passes	....		1	
Downcomer dimension,	Width m	Length m	Area m2	
Side	0.368	2.150	0.540	
Avg. weir length m	....		2.150	
Weir height, m	....		0.051	
Flow path length m	....		2.769	

VALVE TRAY SIZING

Flow path width m	3.095
Tray area, m2	9.650
Tray active area m2	8.570
% flood	74.565
Hole area m2	1.628
Approx # of valves	1375
Tray press loss, m	0.120
Tray press loss, Pa	874.537
Dry press drop, m	0.066
Downcomer clearance m	0.076
Downcomer head loss m	0.007
Downcomer backup m	0.212
Downcomer residence time, sec	3.559
Actual tray efficiency (O'Connell)	0.635
Actual tray efficiency (Chu)	0.572

Equip. 2 Tray No. 36

Tray Loadings	Vapor	Liquid
	108420.051 kg/h	85627.240 kg/h
	53927.463 m3/h	115.607 m3/h
Density	2.010 kg/m3	740.675 kg/m3
System factor		1.000
Valve type : V-1		
Valve material : S.S.		
Valve thickness, gage		12.000
Deck thickness, gage		14.000
Tower internal diameter, m		3.505
Tray spacing, m		0.610
No. of tray liquid passes		1

Downcomer dimension,	Width m	Length m	Area m2
Side	0.368	2.150	0.540

Avg. weir length m	2.150
Weir height, m	0.051
Flow path length m	2.769
Flow path width m	3.095
Tray area, m2	9.650
Tray active area m2	8.570
% flood	74.243
Hole area m2	1.628
Approx # of valves	1375
Tray press loss, m	0.120
Tray press loss, Pa	870.713
Dry press drop, m	0.066
Downcomer clearance m	0.076
Downcomer head loss m	0.007
Downcomer backup m	0.211
Downcomer residence time, sec	3.556
Actual tray efficiency (O'Connell)	0.634
Actual tray efficiency (Chu)	0.571

Equip. 2 Tray No. 37

Tray Loadings	Vapor	Liquid
	108250.932 kg/h	85458.135 kg/h
	53610.269 m3/h	115.349 m3/h

VALVE TRAY SIZING

Density	2.019 kg/m3		740.868 kg/m3
System factor	....		1.000
Valve type : V-1			
Valve material : S.S.			
Valve thickness, gage	....		12.000
Deck thickness, gage	....		14.000
Tower internal diameter, m	....		3.353
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.349	2.048	0.488
Avg. weir length m	....		2.048
Weir height, m	....		0.051
Flow path length m	....		2.654
Flow path width m	....		2.959
Tray area, m2	....		8.829
Tray active area m2	....		7.853
% flood	....		80.218
Hole area m2	....		1.492
Approx # of valves	....		1260
Tray press loss, m	....		0.133
Tray press loss, Pa	....		965.591
Dry press drop, m	....		0.078
Downcomer clearance m	....		0.076
Downcomer head loss m	....		0.007
Downcomer backup m	....		0.226
Downcomer residence time, sec	....		3.444
Actual tray efficiency (O'Connell)	....		0.633
Actual tray efficiency (Chu)	....		0.571

Equip. 2 Tray No. 38

Tray Loadings	Vapor		Liquid
	108074.144 kg/h		85281.347 kg/h
	53296.588 m3/h		115.075 m3/h
Density	2.028 kg/m3		741.091 kg/m3
System factor	....		1.000
Valve type : V-1			
Valve material : S.S.			
Valve thickness, gage	....		12.000
Deck thickness, gage	....		14.000
Tower internal diameter, m	....		3.353
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.349	2.048	0.488
Avg. weir length m	....		2.048
Weir height, m	....		0.051
Flow path length m	....		2.654
Flow path width m	....		2.959
Tray area, m2	....		8.829
Tray active area m2	....		7.853
% flood	....		79.866
Hole area m2	....		1.492
Approx # of valves	....		1260
Tray press loss, m	....		0.132

VALVE TRAY SIZING

Tray press loss, Pa	961.081
Dry press drop, m	0.077
Downcomer clearance m	0.076
Downcomer head loss m	0.007
Downcomer backup m	0.225
Downcomer residence time, sec	3.441
Actual tray efficiency (O'Connell)	0.633
Actual tray efficiency (Chu)	0.570

Equip. 2 Tray No. 39

Tray Loadings	Vapor		Liquid
	107888.760 kg/h		85095.963 kg/h
	52986.207 m3/h		114.785 m3/h
Density	2.036 kg/m3		741.350 kg/m3
System factor			1.000
Valve type : V-1			
Valve material : S.S.			
Valve thickness, gage			12.000
Deck thickness, gage			14.000
Tower internal diameter, m			3.353
Tray spacing, m			0.610
No. of tray liquid passes			1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.349	2.048	0.488
Avg. weir length m			2.048
Weir height, m			0.051
Flow path length m			2.654
Flow path width m			2.959
Tray area, m2			8.829
Tray active area m2			7.853
% flood			79.511
Hole area m2			1.492
Approx # of valves			1260
Tray press loss, m			0.132
Tray press loss, Pa			956.566
Dry press drop, m			0.077
Downcomer clearance m			0.076
Downcomer head loss m			0.007
Downcomer backup m			0.225
Downcomer residence time, sec			3.438
Actual tray efficiency (O'Connell)			0.632
Actual tray efficiency (Chu)			0.570

Equip. 2 Tray No. 40

Tray Loadings	Vapor	Liquid
	107693.935 kg/h	84901.131 kg/h
	52678.925 m3/h	114.476 m3/h
Density	2.044 kg/m3	741.647 kg/m3
System factor		1.000
Valve type : V-1		
Valve material : S.S.		
Valve thickness, gage		12.000
Deck thickness, gage		14.000
Tower internal diameter, m		3.353

VALVE TRAY SIZING

Tray spacing, m	....	0.610
No. of tray liquid passes	....	1

Downcomer dimension,	Width m	Length m	Area m2
Side	0.349	2.048	0.488

Avg. weir length m	....	2.048
Weir height, m	....	0.051
Flow path length m	....	2.654
Flow path width m	....	2.959
Tray area, m2	....	8.829
Tray active area m2	....	7.853
% flood	....	79.154
Hole area m2	....	1.492
Approx # of valves	....	1260
Tray press loss, m	....	0.131
Tray press loss, Pa	....	952.040
Dry press drop, m	....	0.076
Downcomer clearance m	....	0.076
Downcomer head loss m	....	0.007
Downcomer backup m	....	0.224
Downcomer residence time, sec	....	3.435
Actual tray efficiency (O'Connell)	....	0.631
Actual tray efficiency (Chu)	....	0.569

Equip. 2 Tray No. 41

Tray Loadings	Vapor	Liquid
	107489.393 kg/h	84696.582 kg/h
	52374.828 m3/h	114.148 m3/h
Density	2.052 kg/m3	741.989 kg/m3
System factor	....	1.000

Valve type : V-1
Valve material : S.S.

Valve thickness, gage	....	12.000
Deck thickness, gage	....	14.000
Tower internal diameter, m	....	3.353
Tray spacing, m	....	0.610
No. of tray liquid passes	....	1

Downcomer dimension,	Width m	Length m	Area m2
Side	0.349	2.048	0.488

Avg. weir length m	....	2.048
Weir height, m	....	0.051
Flow path length m	....	2.654
Flow path width m	....	2.959
Tray area, m2	....	8.829
Tray active area m2	....	7.853
% flood	....	78.793
Hole area m2	....	1.492
Approx # of valves	....	1260
Tray press loss, m	....	0.130
Tray press loss, Pa	....	947.503
Dry press drop, m	....	0.075
Downcomer clearance m	....	0.076
Downcomer head loss m	....	0.007
Downcomer backup m	....	0.223
Downcomer residence time, sec	....	3.433
Actual tray efficiency (O'Connell)	....	0.631

VALVE TRAY SIZING

Actual tray efficiency (Chu)	....	0.568

Equip. 2 Tray No. 42

Tray Loadings	Vapor		Liquid
	107274.007 kg/h		84481.225 kg/h
	52073.688 m3/h		113.798 m3/h
Density	2.060 kg/m3		742.380 kg/m3
System factor	....		1.000
Valve type : V-1			
Valve material : S.S.			
Valve thickness, gage	....		12.000
Deck thickness, gage	....		14.000
Tower internal diameter, m	....		3.353
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.349	2.048	0.488
Avg. weir length m	....		2.048
Weir height, m	....		0.051
Flow path length m	....		2.654
Flow path width m	....		2.959
Tray area, m2	....		8.829
Tray active area m2	....		7.853
% flood	....		78.429
Hole area m2	....		1.492
Approx # of valves	....		1260
Tray press loss, m	....		0.130
Tray press loss, Pa	....		942.948
Dry press drop, m	....		0.075
Downcomer clearance m	....		0.076
Downcomer head loss m	....		0.007
Downcomer backup m	....		0.222
Downcomer residence time, sec	....		3.431
Actual tray efficiency (O'Connell)	....		0.630
Actual tray efficiency (Chu)	....		0.568

Equip. 2 Tray No. 43

Tray Loadings	Vapor		Liquid
	107046.864 kg/h		84254.088 kg/h
	51775.396 m3/h		113.423 m3/h
Density	2.068 kg/m3		742.828 kg/m3
System factor	....		1.000
Valve type : V-1			
Valve material : S.S.			
Valve thickness, gage	....		12.000
Deck thickness, gage	....		14.000
Tower internal diameter, m	....		3.353
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.349	2.048	0.488
Avg. weir length m	....		2.048
Weir height, m	....		0.051
Flow path length m	....		2.654

VALVE TRAY SIZING

Flow path width m	....	2.959
Tray area, m2	....	8.829
Tray active area m2	....	7.853
% flood	....	78.060
Hole area m2	....	1.492
Approx # of valves	....	1260
Tray press loss, m	....	0.129
Tray press loss, Pa	....	938.369
Dry press drop, m	....	0.074
Downcomer clearance m	....	0.076
Downcomer head loss m	....	0.007
Downcomer backup m	....	0.221
Downcomer residence time, sec	....	3.430
Actual tray efficiency (O'Connell)	....	0.629
Actual tray efficiency (Chu)	....	0.567

Equip. 2 Tray No. 44

Tray Loadings	Vapor		Liquid
	106806.169 kg/h		84013.387 kg/h
	51479.481 m3/h		113.021 m3/h
Density	2.075 kg/m3		743.341 kg/m3
System factor	....		1.000
Valve type : V-1			
Valve material : S.S.			
Valve thickness, gage	....		12.000
Deck thickness, gage	....		14.000
Tower internal diameter, m	....		3.353
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.349	2.048	0.488
Avg. weir length m	....		2.048
Weir height, m	....		0.051
Flow path length m	....		2.654
Flow path width m	....		2.959
Tray area, m2	....		8.829
Tray active area m2	....		7.853
% flood	....		77.686
Hole area m2	....		1.492
Approx # of valves	....		1260
Tray press loss, m	....		0.128
Tray press loss, Pa	....		933.753
Dry press drop, m	....		0.074
Downcomer clearance m	....		0.076
Downcomer head loss m	....		0.007
Downcomer backup m	....		0.221
Downcomer residence time, sec	....		3.429
Actual tray efficiency (O'Connell)	....		0.628
Actual tray efficiency (Chu)	....		0.566

Equip. 2 Tray No. 45

Tray Loadings	Vapor	Liquid
	106551.980 kg/h	83759.191 kg/h
	51186.457 m3/h	112.591 m3/h

VALVE TRAY SIZING

Density	2.082 kg/m3	743.926 kg/m3
System factor	....	1.000
Valve type : V-1		
Valve material : S.S.		
Valve thickness, gage	....	12.000
Deck thickness, gage	....	14.000
Tower internal diameter, m	....	3.353
Tray spacing, m	....	0.610
No. of tray liquid passes	....	1
Downcomer dimension,	Width m Length m	Area m2
Side	0.349 2.048	0.488
Avg. weir length m	....	2.048
Weir height, m	....	0.051
Flow path length m	....	2.654
Flow path width m	....	2.959
Tray area, m2	....	8.829
Tray active area m2	....	7.853
% flood	....	77.305
Hole area m2	....	1.492
Approx # of valves	....	1260
Tray press loss, m	....	0.127
Tray press loss, Pa	....	929.109
Dry press drop, m	....	0.073
Downcomer clearance m	....	0.076
Downcomer head loss m	....	0.007
Downcomer backup m	....	0.220
Downcomer residence time, sec	....	3.428
Actual tray efficiency (O'Connell)	....	0.627
Actual tray efficiency (Chu)	....	0.565

Equip. 2 Tray No. 46

Tray Loadings	Vapor	Liquid
	106281.597 kg/h	83488.814 kg/h
	50895.611 m3/h	112.127 m3/h
Density	2.088 kg/m3	744.595 kg/m3
System factor	....	1.000
Valve type : V-1		
Valve material : S.S.		
Valve thickness, gage	....	12.000
Deck thickness, gage	....	14.000
Tower internal diameter, m	....	3.353
Tray spacing, m	....	0.610
No. of tray liquid passes	....	1
Downcomer dimension,	Width m Length m	Area m2
Side	0.349 2.048	0.488
Avg. weir length m	....	2.048
Weir height, m	....	0.051
Flow path length m	....	2.654
Flow path width m	....	2.959
Tray area, m2	....	8.829
Tray active area m2	....	7.853
% flood	....	76.917
Hole area m2	....	1.492
Approx # of valves	....	1260
Tray press loss, m	....	0.127

VALVE TRAY SIZING

Tray press loss, Pa	....	924.415
Dry press drop, m	....	0.072
Downcomer clearance m	....	0.076
Downcomer head loss m	....	0.007
Downcomer backup m	....	0.219
Downcomer residence time, sec	....	3.428
Actual tray efficiency (O'Connell)	....	0.626
Actual tray efficiency (Chu)	....	0.564

Equip. 2 Tray No. 47

Tray Loadings		Vapor		Liquid
		105994.026 kg/h		83201.258 kg/h
		50607.165 m3/h		111.626 m3/h
Density		2.094 kg/m3		745.359 kg/m3
System factor		....		1.000
Valve type : V-1				
Valve material : S.S.				
Valve thickness, gage		....		12.000
Deck thickness, gage		....		14.000
Tower internal diameter, m		....		3.353
Tray spacing, m		....		0.610
No. of tray liquid passes		....		1
Downcomer dimension,		Width m	Length m	Area m2
Side		0.349	2.048	0.488
Avg. weir length m		....		2.048
Weir height, m		....		0.051
Flow path length m		....		2.654
Flow path width m		....		2.959
Tray area, m2		....		8.829
Tray active area m2		....		7.853
% flood		....		76.520
Hole area m2		....		1.492
Approx # of valves		....		1260
Tray press loss, m		....		0.126
Tray press loss, Pa		....		919.671
Dry press drop, m		....		0.072
Downcomer clearance m		....		0.076
Downcomer head loss m		....		0.007
Downcomer backup m		....		0.218
Downcomer residence time, sec		....		3.428
Actual tray efficiency (O'Connell)		....		0.625
Actual tray efficiency (Chu)		....		0.563

Equip. 2 Tray No. 48

Tray Loadings	Vapor	Liquid
	105686.583 kg/h	82893.814 kg/h
	50320.704 m3/h	111.083 m3/h
Density	2.100 kg/m3	746.232 kg/m3
System factor	....	1.000
Valve type : V-1		
Valve material : S.S.		
Valve thickness, gage	....	12.000
Deck thickness, gage	....	14.000
Tower internal diameter, m	....	3.353

VALVE TRAY SIZING

Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.349	2.048	0.488
Avg. weir length m	....		2.048
Weir height, m	....		0.051
Flow path length m	....		2.654
Flow path width m	....		2.959
Tray area, m2	....		8.829
Tray active area m2	....		7.853
% flood	....		76.113
Hole area m2	....		1.492
Approx # of valves	....		1260
Tray press loss, m	....		0.125
Tray press loss, Pa	....		914.858
Dry press drop, m	....		0.071
Downcomer clearance m	....		0.076
Downcomer head loss m	....		0.007
Downcomer backup m	....		0.217
Downcomer residence time, sec	....		3.430
Actual tray efficiency (O'Connell)	....		0.624
Actual tray efficiency (Chu)	....		0.562

Equip. 2 Tray No. 49

Tray Loadings	Vapor		Liquid
	105355.304 kg/h		82562.536 kg/h
	50035.412 m3/h		110.491 m3/h
Density	2.106 kg/m3		747.231 kg/m3
System factor	....		1.000
Valve type : V-1			
Valve material : S.S.			
Valve thickness, gage	....		12.000
Deck thickness, gage	....		14.000
Tower internal diameter, m	....		3.353
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.349	2.048	0.488
Avg. weir length m	....		2.048
Weir height, m	....		0.051
Flow path length m	....		2.654
Flow path width m	....		2.959
Tray area, m2	....		8.829
Tray active area m2	....		7.853
% flood	....		75.693
Hole area m2	....		1.492
Approx # of valves	....		1260
Tray press loss, m	....		0.124
Tray press loss, Pa	....		909.949
Dry press drop, m	....		0.070
Downcomer clearance m	....		0.076
Downcomer head loss m	....		0.007
Downcomer backup m	....		0.216
Downcomer residence time, sec	....		3.432
Actual tray efficiency (O'Connell)	....		0.623

VALVE TRAY SIZING

Actual tray efficiency (Chu)	....	0.561

Equip. 2 Tray No. 50

Tray Loadings	Vapor	Liquid
	105000.390 kg/h	82207.614 kg/h
	49752.759 m3/h	109.848 m3/h
Density	2.110 kg/m3	748.377 kg/m3
System factor	....	1.000
Valve type : V-1		
Valve material : S.S.		
Valve thickness, gage	....	12.000
Deck thickness, gage	....	14.000
Tower internal diameter, m	....	3.353
Tray spacing, m	....	0.610
No. of tray liquid passes	....	1

Downcomer dimension,	Width m	Length m	Area m2
Side	0.349	2.048	0.488

Avg. weir length m	....	2.048
Weir height, m	....	0.051
Flow path length m	....	2.654
Flow path width m	....	2.959
Tray area, m2	....	8.829
Tray active area m2	....	7.853
% flood	....	75.259
Hole area m2	....	1.492
Approx # of valves	....	1260
Tray press loss, m	....	0.123
Tray press loss, Pa	....	904.967
Dry press drop, m	....	0.069
Downcomer clearance m	....	0.076
Downcomer head loss m	....	0.007
Downcomer backup m	....	0.215
Downcomer residence time, sec	....	3.434
Actual tray efficiency (O'Connell)	....	0.621
Actual tray efficiency (Chu)	....	0.560

Equip. 2 Tray No. 51

Tray Loadings	Vapor	Liquid
	104614.673 kg/h	81821.905 kg/h
	49471.041 m3/h	109.140 m3/h
Density	2.115 kg/m3	749.695 kg/m3
System factor	....	1.000
Valve type : V-1		
Valve material : S.S.		
Valve thickness, gage	....	12.000
Deck thickness, gage	....	14.000
Tower internal diameter, m	....	3.353
Tray spacing, m	....	0.610
No. of tray liquid passes	....	1

Downcomer dimension,	Width m	Length m	Area m2
Side	0.349	2.048	0.488

Avg. weir length m	....	2.048
Weir height, m	....	0.051
Flow path length m	....	2.654

VALVE TRAY SIZING

Flow path width m	2.959
Tray area, m2	8.829
Tray active area m2	7.853
% flood	74.809
Hole area m2	1.492
Approx # of valves	1260
Tray press loss, m	0.122
Tray press loss, Pa	899.855
Dry press drop, m	0.069
Downcomer clearance m	0.076
Downcomer head loss m	0.007
Downcomer backup m	0.214
Downcomer residence time, sec	3.438
Actual tray efficiency (O'Connell)	0.620
Actual tray efficiency (Chu)	0.558

Equip. 2 Tray No. 52

Tray Loadings	Vapor	Liquid
	104192.953 kg/h	81400.177 kg/h
	49190.034 m3/h	108.358 m3/h
Density	2.118 kg/m3	751.216 kg/m3
System factor		1.000
Valve type : V-1		
Valve material : S.S.		
Valve thickness, gage		12.000
Deck thickness, gage		14.000
Tower internal diameter, m		3.353
Tray spacing, m		0.610
No. of tray liquid passes		1

Downcomer dimension,	Width m	Length m	Area m2
Side	0.349	2.048	0.488

Avg. weir length m	2.048
Weir height, m	0.051
Flow path length m	2.654
Flow path width m	2.959
Tray area, m2	8.829
Tray active area m2	7.853
% flood	74.337
Hole area m2	1.492
Approx # of valves	1260
Tray press loss, m	0.121
Tray press loss, Pa	894.587
Dry press drop, m	0.068
Downcomer clearance m	0.076
Downcomer head loss m	0.007
Downcomer backup m	0.212
Downcomer residence time, sec	3.443
Actual tray efficiency (O'Connell)	0.618
Actual tray efficiency (Chu)	0.557

Equip. 2 Tray No. 53

Tray Loadings	Vapor	Liquid
	103729.459 kg/h	80936.691 kg/h
	48909.928 m3/h	107.488 m3/h

VALVE TRAY SIZING

Density	2.121 kg/m3		752.980 kg/m3
System factor	....		1.000
Valve type : V-1			
Valve material : S.S.			
Valve thickness, gage	....		12.000
Deck thickness, gage	....		14.000
Tower internal diameter, m	....		3.353
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.349	2.048	0.488
Avg. weir length m	....		2.048
Weir height, m	....		0.051
Flow path length m	....		2.654
Flow path width m	....		2.959
Tray area, m2	....		8.829
Tray active area m2	....		7.853
% flood	....		73.840
Hole area m2	....		1.492
Approx # of valves	....		1260
Tray press loss, m	....		0.120
Tray press loss, Pa	....		889.140
Dry press drop, m	....		0.067
Downcomer clearance m	....		0.076
Downcomer head loss m	....		0.007
Downcomer backup m	....		0.211
Downcomer residence time, sec	....		3.450
Actual tray efficiency (O'Connell)	....		0.616
Actual tray efficiency (Chu)	....		0.555

Equip. 2 Tray No. 54

Tray Loadings	Vapor		Liquid
	103215.341 kg/h		80422.579 kg/h
	48630.427 m3/h		106.515 m3/h
Density	2.122 kg/m3		755.039 kg/m3
System factor	....		1.000
Valve type : V-1			
Valve material : S.S.			
Valve thickness, gage	....		12.000
Deck thickness, gage	....		14.000
Tower internal diameter, m	....		3.200
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.330	1.947	0.438
Avg. weir length m	....		1.947
Weir height, m	....		0.051
Flow path length m	....		2.540
Flow path width m	....		2.822
Tray area, m2	....		8.045
Tray active area m2	....		7.168
% flood	....		79.875
Hole area m2	....		1.362
Approx # of valves	....		1150
Tray press loss, m	....		0.134

VALVE TRAY SIZING

Tray press loss, Pa	....	989.963
Dry press drop, m	....	0.079
Downcomer clearance m	....	0.076
Downcomer head loss m	....	0.007
Downcomer backup m	....	0.226
Downcomer residence time, sec	....	3.347
Actual tray efficiency (O'Connell)	....	0.614
Actual tray efficiency (Chu)	....	0.553

Equip. 2 Tray No. 55

Tray Loadings	Vapor		Liquid	
	102637.918	kg/h	79845.156	kg/h
	48350.851	m3/h	105.412	m3/h
Density	2.123	kg/m3	757.457	kg/m3
System factor	....		1.000	
Valve type : V-1				
Valve material : S.S.				
Valve thickness, gage	....		12.000	
Deck thickness, gage	....		14.000	
Tower internal diameter, m	....		3.200	
Tray spacing, m	....		0.610	
No. of tray liquid passes	....		1	
Downcomer dimension,	Width m	Length m	Area m2	
Side	0.330	1.947	0.438	
Avg. weir length m	....		1.947	
Weir height, m	....		0.051	
Flow path length m	....		2.540	
Flow path width m	....		2.822	
Tray area, m2	....		8.045	
Tray active area m2	....		7.168	
% flood	....		79.288	
Hole area m2	....		1.362	
Approx # of valves	....		1150	
Tray press loss, m	....		0.132	
Tray press loss, Pa	....		982.857	
Dry press drop, m	....		0.078	
Downcomer clearance m	....		0.076	
Downcomer head loss m	....		0.007	
Downcomer backup m	....		0.224	
Downcomer residence time, sec	....		3.356	
Actual tray efficiency (O'Connell)	....		0.612	
Actual tray efficiency (Chu)	....		0.551	

Equip. 2 Tray No. 56

Tray Loadings	Vapor		Liquid	
	101980.435	kg/h	79187.667	kg/h
	48070.722	m3/h	104.150	m3/h
Density	2.121	kg/m3	760.325	kg/m3
System factor	....		1.000	
Valve type : V-1				
Valve material : S.S.				
Valve thickness, gage	....		12.000	
Deck thickness, gage	....		14.000	
Tower internal diameter, m	....		3.200	

VALVE TRAY SIZING

Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.330	1.947	0.438
Avg. weir length m	....		1.947
Weir height, m	....		0.051
Flow path length m	....		2.540
Flow path width m	....		2.822
Tray area, m2	....		8.045
Tray active area m2	....		7.168
% flood	....		78.663
Hole area m2	....		1.362
Approx # of valves	....		1150
Tray press loss, m	....		0.131
Tray press loss, Pa	....		975.295
Dry press drop, m	....		0.077
Downcomer clearance m	....		0.076
Downcomer head loss m	....		0.007
Downcomer backup m	....		0.222
Downcomer residence time, sec	....		3.367
Actual tray efficiency (O'Connell)	....		0.609
Actual tray efficiency (Chu)	....		0.548

Equip. 2 Tray No. 57

Tray Loadings	Vapor		Liquid
	101217.996 kg/h		78425.221 kg/h
	47789.085 m3/h		102.682 m3/h
Density	2.118 kg/m3		763.766 kg/m3
System factor	....		1.000
Valve type : V-1			
Valve material : S.S.			
Valve thickness, gage	....		12.000
Deck thickness, gage	....		14.000
Tower internal diameter, m	....		3.200
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.330	1.947	0.438
Avg. weir length m	....		1.947
Weir height, m	....		0.051
Flow path length m	....		2.540
Flow path width m	....		2.822
Tray area, m2	....		8.045
Tray active area m2	....		7.168
% flood	....		77.983
Hole area m2	....		1.362
Approx # of valves	....		1150
Tray press loss, m	....		0.129
Tray press loss, Pa	....		967.118
Dry press drop, m	....		0.076
Downcomer clearance m	....		0.076
Downcomer head loss m	....		0.007
Downcomer backup m	....		0.220
Downcomer residence time, sec	....		3.381
Actual tray efficiency (O'Connell)	....		0.605

VALVE TRAY SIZING

Actual tray efficiency (Chu)	....	0.545

Equip. 2 Tray No. 58

Tray Loadings	Vapor			Liquid
	100309.819 kg/h			77517.058 kg/h
	47502.823 m3/h			100.940 m3/h
Density	2.112 kg/m3			767.953 kg/m3
System factor	....			1.000
Valve type : V-1				
Valve material : S.S.				
Valve thickness, gage	....			12.000
Deck thickness, gage	....			14.000
Tower internal diameter, m	....			3.200
Tray spacing, m	....			0.610
No. of tray liquid passes	....			1
Downcomer dimension,	Width m	Length m		Area m2
Side	0.330	1.947		0.438
Avg. weir length m	....			1.947
Weir height, m	....			0.051
Flow path length m	....			2.540
Flow path width m	....			2.822
Tray area, m2	....			8.045
Tray active area m2	....			7.168
% flood	....			77.226
Hole area m2	....			1.362
Approx # of valves	....			1150
Tray press loss, m	....			0.127
Tray press loss, Pa	....			958.035
Dry press drop, m	....			0.074
Downcomer clearance m	....			0.076
Downcomer head loss m	....			0.006
Downcomer backup m	....			0.218
Downcomer residence time, sec	....			3.400
Actual tray efficiency (O'Connell)	....			0.601
Actual tray efficiency (Chu)	....			0.541

Equip. 2 Tray No. 59

Tray Loadings	Vapor			Liquid
	99211.651 kg/h			76418.882 kg/h
	47216.541 m3/h			98.843 m3/h
Density	2.101 kg/m3			773.136 kg/m3
System factor	....			1.000
Valve type : V-1				
Valve material : S.S.				
Valve thickness, gage	....			12.000
Deck thickness, gage	....			14.000
Tower internal diameter, m	....			3.200
Tray spacing, m	....			0.610
No. of tray liquid passes	....			1
Downcomer dimension,	Width m	Length m		Area m2
Side	0.330	1.947		0.438
Avg. weir length m	....			1.947
Weir height, m	....			0.051
Flow path length m	....			2.540

VALVE TRAY SIZING

Flow path width m	2.822
Tray area, m2	8.045
Tray active area m2	7.168
% flood	76.375
Hole area m2	1.362
Approx # of valves	1150
Tray press loss, m	0.125
Tray press loss, Pa	947.843
Dry press drop, m	0.072
Downcomer clearance m	0.076
Downcomer head loss m	0.006
Downcomer backup m	0.215
Downcomer residence time, sec	3.426
Actual tray efficiency (O'Connell)	0.595
Actual tray efficiency (Chu)	0.535

Equip. 2 Tray No. 60

Tray Loadings	Vapor	Liquid
	97829.392 kg/h	75036.623 kg/h
	46928.259 m3/h	96.238 m3/h
Density	2.085 kg/m3	779.698 kg/m3
System factor		1.000

Valve type : V-1
Valve material : S.S.

Valve thickness, gage			12.000
Deck thickness, gage			14.000
Tower internal diameter, m			3.200
Tray spacing, m			0.610
No. of tray liquid passes			1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.330	1.947	0.438
Avg. weir length m			1.947
Weir height, m			0.051
Flow path length m			2.540
Flow path width m			2.822
Tray area, m2			8.045
Tray active area m2			7.168
% flood			75.388
Hole area m2			1.362
Approx # of valves			1150
Tray press loss, m			0.122
Tray press loss, Pa			935.922
Dry press drop, m			0.070
Downcomer clearance m			0.076
Downcomer head loss m			0.006
Downcomer backup m			0.211
Downcomer residence time, sec			3.461
Actual tray efficiency (O'Connell)			0.588
Actual tray efficiency (Chu)			0.529

Equip. 2 Tray No. 61

Tray Loadings	Vapor	Liquid
	96002.896 kg/h	73210.135 kg/h
	46635.858 m3/h	92.878 m3/h

VALVE TRAY SIZING

Density	2.059 kg/m3		788.244 kg/m3
System factor	....		1.000
Valve type : V-1			
Valve material : S.S.			
Valve thickness, gage	....		12.000
Deck thickness, gage	....		14.000
Tower internal diameter, m	....		3.200
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.330	1.947	0.438
Avg. weir length m	....		1.947
Weir height, m	....		0.051
Flow path length m	....		2.540
Flow path width m	....		2.822
Tray area, m2	....		8.045
Tray active area m2	....		7.168
% flood	....		74.196
Hole area m2	....		1.362
Approx # of valves	....		1150
Tray press loss, m	....		0.119
Tray press loss, Pa	....		921.210
Dry press drop, m	....		0.068
Downcomer clearance m	....		0.076
Downcomer head loss m	....		0.005
Downcomer backup m	....		0.207
Downcomer residence time, sec	....		3.512
Actual tray efficiency (O'Connell)	....		0.578
Actual tray efficiency (Chu)	....		0.519

Equip. 2 Tray No. 62

Tray Loadings	Vapor		Liquid
	91204.541 kg/h		100865.165 kg/h
	44858.189 m3/h		126.546 m3/h
Density	2.033 kg/m3		797.064 kg/m3
System factor	....		1.000
Valve type : V-1			
Valve material : S.S.			
Valve thickness, gage	....		12.000
Deck thickness, gage	....		14.000
Tower internal diameter, m	....		3.200
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.387	2.088	0.554
Avg. weir length m	....		2.088
Weir height, m	....		0.051
Flow path length m	....		2.426
Flow path width m	....		2.860
Tray area, m2	....		8.045
Tray active area m2	....		6.937
% flood	....		75.686
Hole area m2	....		1.318
Approx # of valves	....		1113
Tray press loss, m	....		0.122

VALVE TRAY SIZING

Tray press loss, Pa	954.850
Dry press drop, m	0.065
Downcomer clearance m	0.076
Downcomer head loss m	0.009
Downcomer backup m	0.218
Downcomer residence time, sec	3.439
Actual tray efficiency (O'Connell)	0.559
Actual tray efficiency (Chu)	0.567

Equip. 2 Tray No. 63

Tray Loadings	Vapor		Liquid
	88236.913 kg/h		97897.523 kg/h
	44520.434 m3/h		120.493 m3/h
Density	1.982 kg/m3		812.475 kg/m3
System factor			1.000
Valve type : V-1			
Valve material : S.S.			
Valve thickness, gage			12.000
Deck thickness, gage			14.000
Tower internal diameter, m			3.048
Tray spacing, m			0.610
No. of tray liquid passes			1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.368	1.987	0.501
Avg. weir length m			1.987
Weir height, m			0.051
Flow path length m			2.311
Flow path width m			2.723
Tray area, m2			7.297
Tray active area m2			6.295
% flood			80.473
Hole area m2			1.196
Approx # of valves			1010
Tray press loss, m			0.132
Tray press loss, Pa			1048.541
Dry press drop, m			0.075
Downcomer clearance m			0.076
Downcomer head loss m			0.009
Downcomer backup m			0.228
Downcomer residence time, sec			3.410
Actual tray efficiency (O'Connell)			0.544
Actual tray efficiency (Chu)			0.552

Equip. 2 Tray No. 64

Tray Loadings	Vapor	Liquid
	83230.855 kg/h	92891.479 kg/h
	44188.127 m3/h	110.695 m3/h
Density	1.884 kg/m3	839.165 kg/m3
System factor		1.000
Valve type : V-1		
Valve material : S.S.		
Valve thickness, gage		12.000
Deck thickness, gage		14.000
Tower internal diameter, m		3.048

VALVE TRAY SIZING

Tray spacing, m		....		0.610
No. of tray liquid passes		....		1
Downcomer dimension,	Width m		Length m	Area m2
Side	0.368		1.987	0.501
Avg. weir length m		....		1.987
Weir height, m		....		0.051
Flow path length m		....		2.311
Flow path width m		....		2.723
Tray area, m2		....		7.297
Tray active area m2		....		6.295
% flood		....		76.865
Hole area m2		....		1.196
Approx # of valves		....		1010
Tray press loss, m		....		0.123
Tray press loss, Pa		....		1008.871
Dry press drop, m		....		0.068
Downcomer clearance m		....		0.076
Downcomer head loss m		....		0.007
Downcomer backup m		....		0.215
Downcomer residence time, sec		....		3.510
Actual tray efficiency (O'Connell)		....		0.516
Actual tray efficiency (Chu)		....		0.524

Equip. 2 Tray No. 65

Tray Loadings	Vapor		Liquid	
	75420.618 kg/h		85081.242 kg/h	
	44062.235 m3/h		96.042 m3/h	
Density	1.712 kg/m3		885.876 kg/m3	
System factor		....	1.000	
Valve type : V-1				
Valve material : S.S.				
Valve thickness, gage		....	12.000	
Deck thickness, gage		....	14.000	
Tower internal diameter, m		....	2.896	
Tray spacing, m		....	0.610	
No. of tray liquid passes		....	1	
Downcomer dimension,	Width m	Length m	Area m2	
Side	0.330	1.841	0.415	
Avg. weir length m		....	1.841	
Weir height, m		....	0.051	
Flow path length m		....	2.235	
Flow path width m		....	2.574	
Tray area, m2		....	6.585	
Tray active area m2		....	5.754	
% flood		....	77.983	
Hole area m2		....	1.093	
Approx # of valves		....	923	
Tray press loss, m		....	0.123	
Tray press loss, Pa		....	1066.524	
Dry press drop, m		....	0.070	
Downcomer clearance m		....	0.076	
Downcomer head loss m		....	0.006	
Downcomer backup m		....	0.213	
Downcomer residence time, sec		....	3.320	
Actual tray efficiency (O'Connell)		....	0.469	

VALVE TRAY SIZING

Actual tray efficiency (Chu) 0.475

Equip. 2 Tray No. 66

Tray Loadings	Vapor	Liquid
	67919.199 kg/h	77579.824 kg/h
	44420.773 m3/h	82.329 m3/h
Density	1.529 kg/m3	942.316 kg/m3
System factor	....	1.000
Valve type : V-1		
Valve material : S.S.		
Valve thickness, gage	....	12.000
Deck thickness, gage	....	14.000
Tower internal diameter, m	....	2.743
Tray spacing, m	....	0.610
No. of tray liquid passes	....	1

Downcomer dimension,	Width m	Length m	Area m2
Side	0.311	1.740	0.370

Avg. weir length m	....	1.740
Weir height, m	....	0.051
Flow path length m	....	2.121
Flow path width m	....	2.438
Tray area, m2	....	5.910
Tray active area m2	....	5.170
% flood	....	80.415
Hole area m2	....	0.982
Approx # of valves	....	830
Tray press loss, m	....	0.125
Tray press loss, Pa	....	1152.016
Dry press drop, m	....	0.073
Downcomer clearance m	....	0.076
Downcomer head loss m	....	0.005
Downcomer backup m	....	0.212
Downcomer residence time, sec	....	3.427
Actual tray efficiency (O'Connell)	....	0.416
Actual tray efficiency (Chu)	....	0.421

Equip. 2 Tray No. 67

Tray Loadings	Vapor	Liquid
	63979.764 kg/h	73640.381 kg/h
	44944.361 m3/h	75.926 m3/h
Density	1.424 kg/m3	969.891 kg/m3
System factor	....	1.000
Valve type : V-1		
Valve material : S.S.		
Valve thickness, gage	....	12.000
Deck thickness, gage	....	14.000
Tower internal diameter, m	....	2.743
Tray spacing, m	....	0.610
No. of tray liquid passes	....	1

Downcomer dimension,	Width m	Length m	Area m2
Side	0.292	1.692	0.337

Avg. weir length m	....	1.692
Weir height, m	....	0.051
Flow path length m	....	2.159

VALVE TRAY SIZING

```
 Flow path width    m            ................      2.425
 Tray area,  m2                  ................      5.910
 Tray active area  m2            ................      5.236
 % flood                         ................     77.545
 Hole area  m2                   ................      0.995
 Approx # of valves              ................        840
 Tray press loss,   m            ................      0.116
 Tray press loss, Pa             ................   1107.699
 Dry press drop,   m             ................      0.066
 Downcomer clearance   m         ................      0.076
 Downcomer head loss   m         ................      0.005
 Downcomer backup   m            ................      0.202
 Downcomer residence time, sec   ................      3.230
 Actual tray efficiency (O'Connell) ...........        0.391
 Actual tray efficiency (Chu)       ...........        0.395

             Equip.   2   Tray No.  68

 Tray Loadings                        Vapor              Liquid
                                  60305.531 kg/h     69966.134 kg/h
                                  45174.579 m3/h        71.874 m3/h
 Density                              1.335 kg/m3      973.461 kg/m3
 System factor                   ................      1.000
 Valve type      :  V-1
 Valve material  :  S.S.
 Valve thickness, gage           ................     12.000
 Deck  thickness, gage           ................     14.000
 Tower internal diameter,   m    ................      2.743
 Tray spacing,   m               ................      0.610
 No. of tray liquid passes       ................          1
 Downcomer dimension,         Width  m    Length  m   Area m2
               Side            0.292       1.692       0.337
 Avg. weir length    m           ................      1.692
 Weir height,   m                ................      0.051
 Flow path length    m           ................      2.159
 Flow path width    m            ................      2.425
 Tray area,  m2                  ................      5.910
 Tray active area  m2            ................      5.236
 % flood                         ................     76.147
 Hole area  m2                   ................      0.995
 Approx # of valves              ................        840
 Tray press loss,   m            ................      0.112
 Tray press loss, Pa             ................   1066.043
 Dry press drop,   m             ................      0.063
 Downcomer clearance   m         ................      0.076
 Downcomer head loss   m         ................      0.004
 Downcomer backup   m            ................      0.196
 Downcomer residence time, sec   ................      3.304
 Actual tray efficiency (O'Connell) ...........        0.382
 Actual tray efficiency (Chu)       ...........        0.386

             Equip.   2   Tray No.  69

 Tray Loadings                        Vapor              Liquid
                                  55104.003 kg/h     64764.613 kg/h
                                  45344.750 m3/h        66.968 m3/h
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VALVE TRAY SIZING

Density	1.215 kg/m3		967.099 kg/m3
System factor	....		1.000
Valve type : V-1			
Valve material : S.S.			
Valve thickness, gage	....		12.000
Deck thickness, gage	....		14.000
Tower internal diameter, m	....		2.743
Tray spacing, m	....		0.610
No. of tray liquid passes	....		1
Downcomer dimension,	Width m	Length m	Area m2
Side	0.273	1.643	0.306
Avg. weir length m	....		1.643
Weir height, m	....		0.051
Flow path length m	....		2.197
Flow path width m	....		2.412
Tray area, m2	....		5.910
Tray active area m2	....		5.299
% flood	....		74.316
Hole area m2	....		1.007
Approx # of valves	....		850
Tray press loss, m	....		0.105
Tray press loss, Pa	....		993.076
Dry press drop, m	....		0.056
Downcomer clearance m	....		0.076
Downcomer head loss m	....		0.004
Downcomer backup m	....		0.188
Downcomer residence time, sec	....		3.079
Actual tray efficiency (O'Connell)	....		0.377
Actual tray efficiency (Chu)	....		0.380

HEATING CURVES SUMMARY

Eqp # 1 Unit type : SCDS Unit name: AS-601

Condenser

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	124.3	419000.0	3.26E+004	97360	0	1.0000	1.0000
2	124.2	418631.6	2.19E+004	71344	26016	0.6771	0.7328
3	124.0	418263.2	2.14E+004	69663	27697	0.6591	0.7155
4	123.8	417894.7	2.07E+004	67862	29498	0.6401	0.6970
5	123.7	417526.3	2.01E+004	65926	31434	0.6199	0.6771
6	123.5	417157.9	1.94E+004	63838	33522	0.5983	0.6557
7	123.3	416789.5	1.86E+004	61579	35781	0.5753	0.6325
8	123.2	416421.1	1.78E+004	59127	38234	0.5506	0.6073
9	123.0	416052.6	1.69E+004	56456	40904	0.5240	0.5799
10	122.8	415684.2	1.60E+004	53538	43822	0.4953	0.5499
11	122.6	415315.8	1.50E+004	50336	47024	0.4641	0.5170
12	122.5	414947.3	1.39E+004	46820	50541	0.4302	0.4809
13	122.3	414578.9	1.27E+004	42941	54419	0.3932	0.4411
14	122.1	414210.5	1.13E+004	38643	58717	0.3526	0.3969
15	122.0	413842.1	9.90E+003	33876	63484	0.3080	0.3479
16	121.8	413473.7	8.31E+003	28561	68799	0.2587	0.2934
17	121.6	413105.2	6.55E+003	22620	74740	0.2041	0.2323
18	121.5	412736.8	4.60E+003	15957	81404	0.1434	0.1639
19	121.3	412368.4	2.43E+003	8460	88900	0.0757	0.0869
20	121.1	412000.0	1.73	6	97354	0.0001	0.0001

Reboiler

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.	
1	148.9	461939.4	0.000	0	516955	0.0000	0.0000	Bub
2	148.9	462000.5	2.51E+003	4313	512643	0.0084	0.0083	
3	148.9	462061.6	5.01E+003	8622	508334	0.0167	0.0167	
4	148.9	462122.7	7.52E+003	12928	504028	0.0251	0.0250	
5	149.0	462183.8	1.00E+004	17231	499725	0.0334	0.0333	
6	149.0	462244.9	1.25E+004	21530	495425	0.0418	0.0416	
7	149.0	462305.9	1.50E+004	25827	491128	0.0501	0.0500	
8	149.0	462367.0	1.75E+004	30095	486860	0.0584	0.0582	
9	149.0	462428.1	2.00E+004	34414	482542	0.0668	0.0666	
10	149.0	462489.2	2.25E+004	38704	478251	0.0752	0.0749	
11	149.0	462550.3	2.51E+004	42992	473963	0.0836	0.0832	
12	149.0	462611.3	2.76E+004	47278	469677	0.0919	0.0915	
13	149.0	462672.4	3.01E+004	51551	465404	0.1003	0.0997	
14	149.0	462733.5	3.26E+004	55846	461110	0.1086	0.1080	
15	149.1	462794.6	3.51E+004	60127	456828	0.1170	0.1163	
16	149.1	462855.6	3.76E+004	64407	452549	0.1254	0.1246	
17	149.1	462916.8	4.01E+004	68686	448269	0.1337	0.1329	
18	149.1	462977.8	4.26E+004	72963	443992	0.1421	0.1411	
19	149.1	463038.9	4.51E+004	77239	439717	0.1504	0.1494	
20	149.1	463100.0	4.76E+004	81512	435444	0.1588	0.1577	

HEATING CURVES SUMMARY

Eqp # 2 Unit type : SCDS Unit name: AS-602

Condenser

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	80.9	112000.0	2.89E+004	111721	0	1.0000	1.0000
2	80.8	111631.6	1.39E+004	53494	58227	0.4781	0.4788
3	80.7	111263.2	1.01E+004	38730	72990	0.3461	0.3467
4	80.6	110894.7	6.98E+003	26626	85095	0.2378	0.2383
5	80.5	110526.3	4.49E+003	16989	94732	0.1517	0.1521
6	80.4	110157.9	2.47E+003	9152	102568	0.0817	0.0819
7	80.4	109789.5	864.	2937	108784	0.0262	0.0263
8	80.3	109421.1	101.	0	111721	0.0000	0.0000
9	80.2	109052.6	92.4	0	111721	0.0000	0.0000
10	80.1	108684.2	84.0	0	111721	0.0000	0.0000
11	80.0	108315.8	75.6	0	111721	0.0000	0.0000
12	79.9	107947.4	67.2	0	111721	0.0000	0.0000
13	79.8	107578.9	58.7	0	111721	0.0000	0.0000
14	79.7	107210.5	50.4	0	111721	0.0000	0.0000
15	79.7	106842.1	42.0	0	111721	0.0000	0.0000
16	79.6	106473.7	33.6	0	111721	0.0000	0.0000
17	79.5	106105.3	25.2	0	111721	0.0000	0.0000
18	79.4	105736.8	16.8	0	111721	0.0000	0.0000
19	79.3	105368.4	8.40	0	111721	0.0000	0.0000
20	79.2	105000.0	0.01876	0	111721	0.0000	0.0000

Reboiler

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	113.5	174073.5	0.000	0	64765	0.0000	0.0000
2	113.6	174122.3	1.01E+003	2291	62474	0.0298	0.0354
3	113.7	174171.1	2.25E+003	5058	59707	0.0662	0.0781
4	113.7	174219.8	3.64E+003	8117	56648	0.1069	0.1253
5	113.8	174268.6	5.08E+003	11269	53495	0.1495	0.1740
6	113.9	174317.3	6.54E+003	14394	50370	0.1925	0.2223
7	113.9	174366.1	7.97E+003	17399	47365	0.2346	0.2687
8	114.0	174414.9	9.37E+003	20305	44459	0.2761	0.3135
9	114.1	174463.6	1.08E+004	23117	41648	0.3170	0.3569
10	114.1	174512.4	1.21E+004	25858	38906	0.3576	0.3993
11	114.2	174561.2	1.35E+004	28546	36219	0.3982	0.4408
12	114.3	174609.9	1.49E+004	31227	33538	0.4394	0.4822
13	114.4	174658.7	1.63E+004	33915	30850	0.4814	0.5237
14	114.4	174707.5	1.78E+004	36635	28129	0.5246	0.5657
15	114.5	174756.2	1.93E+004	39399	25366	0.5691	0.6083
16	114.6	174805.0	2.08E+004	42262	22503	0.6158	0.6525
17	114.6	174853.7	2.25E+004	45231	19533	0.6650	0.6984
18	114.7	174902.5	2.42E+004	48336	16428	0.7170	0.7463
19	114.8	174951.2	2.61E+004	51614	13150	0.7725	0.7970
20	114.8	175000.0	2.81E+004	55095	9670	0.8320	0.8507

HEATING CURVES SUMMARY

Eqp # 3 Unit type : HTXR Unit name: TT-616

Stream 6410

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	37.0	405000.0	0.000	0	19201	0.0000	0.0000
2	40.0	401368.4	66.5	0	19201	0.0000	0.0000
3	43.0	397736.8	133.	0	19201	0.0000	0.0000
4	46.1	394105.3	200.	0	19201	0.0000	0.0000
5	49.1	390473.7	266.	0	19201	0.0000	0.0000
6	52.1	386842.1	333.	0	19201	0.0000	0.0000
7	55.1	383210.5	400.	0	19201	0.0000	0.0000
8	58.1	379578.9	466.	0	19201	0.0000	0.0000
9	61.2	375947.4	533.	0	19201	0.0000	0.0000
10	64.2	372315.8	600.	0	19201	0.0000	0.0000
11	67.2	368684.2	666.	0	19201	0.0000	0.0000
12	70.2	365052.6	733.	0	19201	0.0000	0.0000
13	73.3	361421.0	800.	0	19201	0.0000	0.0000
14	76.3	357789.5	867.	0	19201	0.0000	0.0000
15	79.3	354157.9	934.	0	19201	0.0000	0.0000
16	82.3	350526.3	1.00E+003	0	19201	0.0000	0.0000
17	85.3	346894.8	1.07E+003	0	19201	0.0000	0.0000
18	88.4	343263.2	1.14E+003	0	19201	0.0000	0.0000
19	91.4	339631.6	1.20E+003	0	19201	0.0000	0.0000
20	94.4	336000.0	1.27E+003	0	19201	0.0000	0.0000

Stream 6207

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	99.4	101000.0	1.27E+003	738	17489	0.0377	0.0405
2	97.3	101000.0	798.	0	18227	0.0000	0.0000
3	95.2	101000.0	754.	0	18227	0.0000	0.0000
4	93.0	101000.0	709.	0	18227	0.0000	0.0000
5	90.9	101000.0	665.	0	18227	0.0000	0.0000
6	88.8	101000.0	620.	0	18227	0.0000	0.0000
7	86.7	101000.0	576.	0	18227	0.0000	0.0000
8	84.5	101000.0	532.	0	18227	0.0000	0.0000
9	82.4	101000.0	487.	0	18227	0.0000	0.0000
10	80.3	101000.0	443.	0	18227	0.0000	0.0000
11	78.2	101000.0	398.	0	18227	0.0000	0.0000
12	76.0	101000.0	354.	0	18227	0.0000	0.0000
13	73.9	101000.0	310.	0	18227	0.0000	0.0000
14	71.8	101000.0	266.	0	18227	0.0000	0.0000
15	69.7	101000.0	221.	0	18227	0.0000	0.0000
16	67.6	101000.0	177.	0	18227	0.0000	0.0000
17	65.4	101000.0	133.	0	18227	0.0000	0.0000
18	63.3	101000.0	88.7	0	18227	0.0000	0.0000
19	61.2	101000.0	44.5	0	18227	0.0000	0.0000
20	59.1	101000.0	0.3095	0	18227	0.0000	0.0000

HEATING CURVES SUMMARY

Eqp # 4 Unit type : HTXR Unit name: TT-627

Stream 6220

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	113.9	170574.0	-1.73	46278	18486	0.6824	0.7146
2	113.9	170389.8	234.	46700	18064	0.6894	0.7211
3	113.8	170205.6	473.	47127	17637	0.6966	0.7277
4	113.8	170021.4	715.	47559	17205	0.7038	0.7343
5	113.8	169837.2	960.	47994	16770	0.7111	0.7411
6	113.8	169653.0	1.21E+003	48435	16329	0.7186	0.7479
7	113.7	169468.7	1.46E+003	48881	15883	0.7261	0.7548
8	113.7	169284.5	1.71E+003	49331	15433	0.7337	0.7617
9	113.7	169100.3	1.97E+003	49787	14977	0.7414	0.7687
10	113.7	168916.1	2.23E+003	50249	14515	0.7492	0.7759
11	113.6	168731.9	2.50E+003	50717	14047	0.7571	0.7831
12	113.6	168547.7	2.77E+003	51190	13574	0.7652	0.7904
13	113.6	168363.5	3.04E+003	51667	13097	0.7733	0.7978
14	113.6	168179.3	3.31E+003	52151	12613	0.7815	0.8052
15	113.5	167995.1	3.59E+003	52641	12123	0.7899	0.8128
16	113.5	167810.9	3.88E+003	53137	11627	0.7984	0.8205
17	113.5	167626.6	4.16E+003	53639	11125	0.8070	0.8282
18	113.5	167442.4	4.46E+003	54148	10616	0.8157	0.8361
19	113.4	167258.2	4.75E+003	54663	10101	0.8245	0.8440
20	113.4	167074.0	5.05E+003	55186	9578	0.8335	0.8521

Eqp # 5 Unit type : HTXR Unit name: TT-615

Stream 6201

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	75.9	584000.0	0.000	0	448694	0.0000	0.0000
2	77.0	580368.4	566.	0	448694	0.0000	0.0000
3	78.1	576736.9	1.13E+003	0	448694	0.0000	0.0000
4	79.2	573105.2	1.70E+003	0	448694	0.0000	0.0000
5	80.3	569473.7	2.27E+003	0	448694	0.0000	0.0000
6	81.5	565842.1	2.83E+003	0	448694	0.0000	0.0000
7	82.6	562210.5	3.40E+003	0	448694	0.0000	0.0000
8	83.7	558578.9	3.97E+003	0	448694	0.0000	0.0000
9	84.8	554947.4	4.54E+003	0	448694	0.0000	0.0000
10	85.9	551315.8	5.10E+003	0	448694	0.0000	0.0000
11	87.0	547684.2	5.67E+003	0	448694	0.0000	0.0000
12	88.1	544052.6	6.24E+003	0	448694	0.0000	0.0000
13	89.2	540421.1	6.81E+003	0	448694	0.0000	0.0000
14	90.3	536789.4	7.38E+003	0	448694	0.0000	0.0000
15	91.4	533157.9	7.95E+003	0	448694	0.0000	0.0000
16	92.6	529526.3	8.52E+003	0	448694	0.0000	0.0000
17	93.7	525894.8	9.09E+003	0	448694	0.0000	0.0000
18	94.8	522263.1	9.66E+003	0	448694	0.0000	0.0000
19	95.9	518631.6	1.02E+004	0	448694	0.0000	0.0000
20	97.0	515000.0	1.08E+004	0	448694	0.0000	0.0000

HEATING CURVES SUMMARY

Stream 216

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	102.0	108000.0	1.08E+004	18227	0	1.0000	1.0000
2	101.9	107631.6	1.08E+004	18227	0	1.0000	1.0000
3	101.7	107263.2	1.08E+004	18227	0	1.0000	1.0000
4	101.6	106894.7	1.08E+004	18227	0	1.0000	1.0000
5	101.5	106526.3	1.08E+004	18227	0	1.0000	1.0000
6	101.3	106157.9	1.08E+004	18227	0	1.0000	1.0000
7	101.2	105789.5	1.08E+004	18227	0	1.0000	1.0000
8	101.0	105421.1	1.08E+004	18227	0	1.0000	1.0000
9	100.9	105052.6	1.08E+004	18227	0	1.0000	1.0000
10	100.8	104684.2	8.93E+003	15248	2979	0.8335	0.8366
11	100.6	104315.8	6.45E+003	11274	6953	0.6120	0.6185
12	100.5	103947.4	4.80E+003	8614	9613	0.4643	0.4726
13	100.4	103578.9	3.62E+003	6718	11509	0.3597	0.3686
14	100.2	103210.5	2.74E+003	5279	12948	0.2807	0.2896
15	100.1	102842.1	2.04E+003	4144	14083	0.2189	0.2274
16	99.9	102473.7	1.48E+003	3223	15004	0.1692	0.1768
17	99.8	102105.3	1.02E+003	2456	15771	0.1280	0.1347
18	99.7	101736.8	625.	1798	16429	0.0932	0.0987
19	99.5	101368.4	289.	1234	16993	0.0635	0.0677
20	99.4	101000.0	-3.10	738	17489	0.0377	0.0405

Eqp # 6 Unit type : HTXR Unit name: TT-613

Stream 6203

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	120.0	446000.0	0.000	0	448694	0.0000	0.0000
2	120.0	442368.4	0.000	0	448694	0.0000	0.0000
3	120.0	438736.8	0.000	0	448694	0.0000	0.0000
4	120.0	435105.3	0.000	0	448694	0.0000	0.0000
5	120.0	431473.7	0.000	0	448694	0.0000	0.0000
6	120.0	427842.1	0.000	0	448694	0.0000	0.0000
7	120.0	424210.5	0.000	0	448694	0.0000	0.0000
8	120.0	420578.9	0.000	0	448694	0.0000	0.0000
9	120.0	416947.4	0.000	0	448694	0.0000	0.0000
10	120.0	413315.8	0.000	0	448694	0.0000	0.0000
11	120.0	409684.2	0.000	0	448694	0.0000	0.0000
12	120.0	406052.6	0.000	0	448694	0.0000	0.0000
13	120.0	402421.1	0.000	0	448694	0.0000	0.0000
14	120.0	398789.5	0.000	0	448694	0.0000	0.0000
15	120.0	395157.9	0.000	0	448694	0.0000	0.0000
16	120.0	391526.3	0.000	0	448694	0.0000	0.0000
17	120.0	387894.8	0.000	0	448694	0.0000	0.0000
18	120.0	384263.2	0.000	0	448694	0.0000	0.0000
19	120.0	380631.6	0.000	0	448694	0.0000	0.0000
20	120.0	377000.0	0.000	0	448694	0.0000	0.0000

HEATING CURVES SUMMARY

Eqp # 7 Unit type : HTXR Unit name: TT-622

Stream 6219

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	113.5	174074.0	0.000	0	64764	0.0000	0.0000
2	113.5	173889.8	407.	923	63841	0.0120	0.0142
3	113.5	173705.6	1.38E+003	3110	61654	0.0405	0.0480
4	113.6	173521.4	2.50E+003	5625	59139	0.0737	0.0869
5	113.6	173337.2	3.73E+003	8347	56417	0.1100	0.1289
6	113.6	173153.0	5.01E+003	11129	53635	0.1476	0.1718
7	113.6	172968.7	6.29E+003	13894	50870	0.1856	0.2145
8	113.6	172784.5	7.55E+003	16566	48198	0.2228	0.2558
9	113.7	172600.3	8.80E+003	19167	45597	0.2597	0.2960
10	113.7	172416.1	1.00E+004	21687	43077	0.2960	0.3349
11	113.7	172231.9	1.12E+004	24143	40621	0.3321	0.3728
12	113.7	172047.7	1.25E+004	26551	38213	0.3680	0.4100
13	113.7	171863.5	1.37E+004	28923	35841	0.4039	0.4466
14	113.8	171679.3	1.49E+004	31294	33470	0.4404	0.4832
15	113.8	171495.1	1.61E+004	33673	31091	0.4775	0.5199
16	113.8	171310.9	1.74E+004	36075	28689	0.5155	0.5570
17	113.8	171126.6	1.87E+004	38521	26243	0.5548	0.5948
18	113.8	170942.4	2.01E+004	41012	23752	0.5953	0.6333
19	113.9	170758.2	2.15E+004	43597	21167	0.6378	0.6732
20	113.9	170574.0	2.30E+004	46278	18486	0.6824	0.7146

Stream 6222

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	124.3	375864.9	2.30E+004	97360	0	1.0000	1.0000
2	124.0	375680.7	2.23E+004	95872	1488	0.9786	0.9847
3	123.7	375496.4	2.16E+004	94364	2996	0.9573	0.9692
4	123.4	375312.2	2.08E+004	92816	4544	0.9358	0.9533
5	123.1	375128.0	2.01E+004	91223	6137	0.9141	0.9370
6	122.8	374943.8	1.93E+004	89568	7792	0.8920	0.9200
7	122.5	374759.6	1.86E+004	87833	9527	0.8694	0.9021
8	122.2	374575.4	1.78E+004	86001	11359	0.8460	0.8833
9	121.9	374391.2	1.69E+004	84044	13316	0.8217	0.8632
10	121.6	374207.0	1.61E+004	81930	15430	0.7961	0.8415
11	121.2	374022.8	1.52E+004	79625	17735	0.7689	0.8178
12	120.9	373838.6	1.42E+004	77073	20287	0.7396	0.7916
13	120.6	373654.3	1.31E+004	74211	23149	0.7077	0.7622
14	120.3	373470.1	1.19E+004	70962	26398	0.6724	0.7289
15	120.0	373285.9	1.06E+004	67208	30152	0.6327	0.6903
16	119.7	373101.7	9.11E+003	62813	34547	0.5874	0.6452
17	119.4	372917.5	7.38E+003	57587	39773	0.5348	0.5915
18	119.1	372733.3	5.35E+003	51289	46071	0.4730	0.5268
19	118.8	372549.1	2.93E+003	43581	53779	0.3990	0.4476
20	118.5	372364.8	0.000	34016	63344	0.3091	0.3494

HEATING CURVES SUMMARY

Eqp # 8 Unit type : HTXR Unit name: TT-624

Stream 6223

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	118.5	372364.8	9.61E+003	34016	63344	0.3091	0.3494
2	118.4	372180.7	9.22E+003	32716	64644	0.2970	0.3360
3	118.4	371996.4	8.81E+003	31374	65986	0.2845	0.3222
4	118.3	371812.2	8.40E+003	29999	67361	0.2718	0.3081
5	118.3	371628.0	7.97E+003	28586	68774	0.2588	0.2936
6	118.2	371443.8	7.53E+003	27131	70229	0.2454	0.2787
7	118.2	371259.6	7.09E+003	25635	71725	0.2316	0.2633
8	118.1	371075.4	6.63E+003	24094	73266	0.2175	0.2475
9	118.1	370891.2	6.15E+003	22501	74859	0.2029	0.2311
10	118.0	370706.9	5.67E+003	20867	76493	0.1880	0.2143
11	118.0	370522.8	5.17E+003	19187	78173	0.1727	0.1971
12	117.9	370338.5	4.66E+003	17454	79906	0.1569	0.1793
13	117.9	370154.3	4.13E+003	15667	81693	0.1407	0.1609
14	117.8	369970.1	3.59E+003	13820	83540	0.1240	0.1419
15	117.8	369785.9	3.03E+003	11922	85438	0.1069	0.1225
16	117.7	369601.7	2.46E+003	9956	87404	0.0892	0.1023
17	117.7	369417.5	1.87E+003	7940	89420	0.0710	0.0816
18	117.6	369233.3	1.26E+003	5850	91510	0.0523	0.0601
19	117.6	369049.1	642.	3706	93654	0.0331	0.0381
20	117.5	368864.8	-1.20	1481	95879	0.0132	0.0152

Eqp # 9 Unit type : HTXR Unit name: TT-623

Stream 6106

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	37.0	653000.0	0.000	0	448694	0.0000	0.0000
2	39.0	649368.4	1.03E+003	0	448694	0.0000	0.0000
3	41.1	645736.8	2.07E+003	0	448694	0.0000	0.0000
4	43.1	642105.2	3.10E+003	0	448694	0.0000	0.0000
5	45.2	638473.6	4.14E+003	0	448694	0.0000	0.0000
6	47.2	634842.1	5.17E+003	0	448694	0.0000	0.0000
7	49.3	631210.5	6.20E+003	0	448694	0.0000	0.0000
8	51.3	627578.9	7.24E+003	0	448694	0.0000	0.0000
9	53.4	623947.4	8.28E+003	0	448694	0.0000	0.0000
10	55.4	620315.8	9.31E+003	0	448694	0.0000	0.0000
11	57.5	616684.2	1.03E+004	0	448694	0.0000	0.0000
12	59.5	613052.6	1.14E+004	0	448694	0.0000	0.0000
13	61.6	609421.1	1.24E+004	0	448694	0.0000	0.0000
14	63.6	605789.4	1.35E+004	0	448694	0.0000	0.0000
15	65.7	602157.9	1.45E+004	0	448694	0.0000	0.0000
16	67.7	598526.3	1.55E+004	0	448694	0.0000	0.0000
17	69.8	594894.7	1.66E+004	0	448694	0.0000	0.0000
18	71.8	591263.1	1.76E+004	0	448694	0.0000	0.0000
19	73.9	587631.6	1.87E+004	0	448694	0.0000	0.0000
20	75.9	584000.0	1.97E+004	0	448694	0.0000	0.0000

HEATING CURVES SUMMARY

Stream 6216

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	80.9	112000.0	1.97E+004	111721	0	1.0000	1.0000
2	80.9	111815.8	1.97E+004	111721	0	1.0000	1.0000
3	80.8	111631.6	1.97E+004	111721	0	1.0000	1.0000
4	80.8	111447.4	1.97E+004	111721	0	1.0000	1.0000
5	80.7	111263.2	1.97E+004	111721	0	1.0000	1.0000
6	80.7	111079.0	1.97E+004	111721	0	1.0000	1.0000
7	80.6	110894.7	1.97E+004	111721	0	1.0000	1.0000
8	80.6	110710.5	1.97E+004	111721	0	1.0000	1.0000
9	80.5	110526.3	1.74E+004	102669	9052	0.9188	0.9190
10	80.5	110342.1	1.49E+004	93334	18387	0.8350	0.8354
11	80.5	110157.9	1.23E+004	83073	28648	0.7430	0.7436
12	80.4	109973.7	1.04E+004	75730	35991	0.6772	0.6778
13	80.4	109789.5	8.63E+003	68928	42793	0.6163	0.6170
14	80.3	109605.3	6.55E+003	60878	50843	0.5442	0.5449
15	80.3	109421.1	5.22E+003	55718	56003	0.4980	0.4987
16	80.2	109236.8	3.98E+003	50910	60811	0.4550	0.4557
17	80.2	109052.6	2.83E+003	46467	65254	0.4153	0.4159
18	80.2	108868.4	1.80E+003	42475	69246	0.3795	0.3802
19	80.1	108684.2	838.	38762	72959	0.3463	0.3470
20	80.1	108500.0	-0.9378	35520	76201	0.3173	0.3179

Eqp # 10 Unit type : HTXR Unit name: TT-626

Stream 6217

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	80.1	108500.0	9.22E+003	35520	76201	0.3173	0.3179
2	80.0	108315.8	7.93E+003	30548	81173	0.2729	0.2734
3	80.0	108131.6	6.78E+003	26077	85644	0.2329	0.2334
4	79.9	107947.4	5.76E+003	22146	89575	0.1978	0.1982
5	79.9	107763.2	4.85E+003	18607	93114	0.1662	0.1665
6	79.8	107578.9	4.06E+003	15573	96148	0.1391	0.1394
7	79.8	107394.7	3.31E+003	12681	99040	0.1132	0.1135
8	79.8	107210.5	2.70E+003	10291	101430	0.0919	0.0921
9	79.7	107026.3	2.14E+003	8142	103579	0.0727	0.0729
10	79.7	106842.1	1.66E+003	6319	105402	0.0564	0.0566
11	79.6	106657.9	1.23E+003	4634	107087	0.0414	0.0415
12	79.6	106473.7	884.	3319	108402	0.0296	0.0297
13	79.5	106289.5	594.	2211	109510	0.0197	0.0198
14	79.5	106105.3	369.	1352	110369	0.0121	0.0121
15	79.4	105921.1	169.	594	111127	0.0053	0.0053
16	79.4	105736.8	54.0	162	111559	0.0014	0.0014
17	79.4	105552.6	8.12	0	111721	0.0000	0.0000
18	79.3	105368.4	3.86	0	111721	0.0000	0.0000
19	79.3	105184.2	-0.3939	0	111721	0.0000	0.0000
20	79.2	105000.0	53.8	227	111494	0.0020	0.0020

HEATING CURVES SUMMARY

Eqp # 11 Unit type : HTXR Unit name:

Stream 6202

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	97.0	515000.0	0.000	0	448694	0.0000	0.0000
2	98.2	511368.4	623.	0	448694	0.0000	0.0000
3	99.4	507736.8	1.25E+003	0	448694	0.0000	0.0000
4	100.6	504105.2	1.87E+003	0	448694	0.0000	0.0000
5	101.8	500473.7	2.49E+003	0	448694	0.0000	0.0000
6	103.1	496842.1	3.12E+003	0	448694	0.0000	0.0000
7	104.3	493210.5	3.74E+003	0	448694	0.0000	0.0000
8	105.5	489578.9	4.37E+003	0	448694	0.0000	0.0000
9	106.7	485947.4	4.99E+003	0	448694	0.0000	0.0000
10	107.9	482315.8	5.62E+003	0	448694	0.0000	0.0000
11	109.1	478684.2	6.25E+003	0	448694	0.0000	0.0000
12	110.3	475052.6	6.87E+003	0	448694	0.0000	0.0000
13	111.5	471421.1	7.50E+003	0	448694	0.0000	0.0000
14	112.7	467789.5	8.13E+003	0	448694	0.0000	0.0000
15	113.9	464157.9	8.76E+003	0	448694	0.0000	0.0000
16	115.2	460526.3	9.39E+003	0	448694	0.0000	0.0000
17	116.4	456894.7	1.00E+004	0	448694	0.0000	0.0000
18	117.6	453263.1	1.06E+004	0	448694	0.0000	0.0000
19	118.8	449631.6	1.13E+004	0	448694	0.0000	0.0000
20	120.0	446000.0	1.19E+004	0	448694	0.0000	0.0000

Stream 6210

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	148.0	463100.0	1.19E+004	0	435442	0.0000	0.0000
2	146.8	459468.4	1.13E+004	0	435442	0.0000	0.0000
3	145.5	455836.8	1.06E+004	0	435442	0.0000	0.0000
4	144.3	452205.2	1.00E+004	0	435442	0.0000	0.0000
5	143.1	448573.7	9.39E+003	0	435442	0.0000	0.0000
6	141.9	444942.1	8.76E+003	0	435442	0.0000	0.0000
7	140.7	441310.5	8.13E+003	0	435442	0.0000	0.0000
8	139.4	437678.9	7.50E+003	0	435442	0.0000	0.0000
9	138.2	434047.3	6.88E+003	0	435442	0.0000	0.0000
10	137.0	430415.8	6.25E+003	0	435442	0.0000	0.0000
11	135.8	426784.2	5.62E+003	0	435442	0.0000	0.0000
12	134.6	423152.6	5.00E+003	0	435442	0.0000	0.0000
13	133.3	419521.0	4.37E+003	0	435442	0.0000	0.0000
14	132.1	415889.4	3.75E+003	0	435442	0.0000	0.0000
15	130.9	412257.9	3.12E+003	0	435442	0.0000	0.0000
16	129.7	408626.3	2.50E+003	0	435442	0.0000	0.0000
17	128.5	404994.7	1.87E+003	0	435442	0.0000	0.0000
18	127.2	401363.2	1.25E+003	0	435442	0.0000	0.0000
19	126.0	397731.6	623.	0	435442	0.0000	0.0000
20	124.8	394100.0	0.3001	0	435442	0.0000	0.0000

HEATING CURVES SUMMARY

Eqp # 12 Unit type : HTXR Unit name: TT-625

Stream 6205

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	94.4	336000.0	0.000	0	19201	0.0000	0.0000
2	95.7	336000.0	30.1	0	19201	0.0000	0.0000
3	97.1	336000.0	60.2	0	19201	0.0000	0.0000
4	98.4	336000.0	90.2	0	19201	0.0000	0.0000
5	99.8	336000.0	120.	0	19201	0.0000	0.0000
6	101.1	336000.0	150.	0	19201	0.0000	0.0000
7	102.5	336000.0	181.	0	19201	0.0000	0.0000
8	103.8	336000.0	211.	0	19201	0.0000	0.0000
9	105.2	336000.0	241.	0	19201	0.0000	0.0000
10	106.5	336000.0	271.	0	19201	0.0000	0.0000
11	107.9	336000.0	301.	0	19201	0.0000	0.0000
12	109.2	336000.0	332.	0	19201	0.0000	0.0000
13	110.6	336000.0	362.	0	19201	0.0000	0.0000
14	111.9	336000.0	392.	0	19201	0.0000	0.0000
15	113.3	336000.0	422.	0	19201	0.0000	0.0000
16	114.6	336000.0	453.	0	19201	0.0000	0.0000
17	116.0	336000.0	483.	0	19201	0.0000	0.0000
18	117.3	336000.0	513.	0	19201	0.0000	0.0000
19	118.7	336000.0	544.	0	19201	0.0000	0.0000
20	120.0	336000.0	574.	0	19201	0.0000	0.0000

Stream 6209

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	149.1	463100.0	574.	0	435442	0.0000	0.0000
2	149.0	463100.0	543.	0	435442	0.0000	0.0000
3	149.0	463100.0	513.	0	435442	0.0000	0.0000
4	148.9	463100.0	483.	0	435442	0.0000	0.0000
5	148.9	463100.0	453.	0	435442	0.0000	0.0000
6	148.8	463100.0	423.	0	435442	0.0000	0.0000
7	148.7	463100.0	393.	0	435442	0.0000	0.0000
8	148.7	463100.0	362.	0	435442	0.0000	0.0000
9	148.6	463100.0	332.	0	435442	0.0000	0.0000
10	148.6	463100.0	302.	0	435442	0.0000	0.0000
11	148.5	463100.0	272.	0	435442	0.0000	0.0000
12	148.5	463100.0	241.	0	435442	0.0000	0.0000
13	148.4	463100.0	211.	0	435442	0.0000	0.0000
14	148.3	463100.0	181.	0	435442	0.0000	0.0000
15	148.3	463100.0	151.	0	435442	0.0000	0.0000
16	148.2	463100.0	121.	0	435442	0.0000	0.0000
17	148.2	463100.0	90.9	0	435442	0.0000	0.0000
18	148.1	463100.0	60.5	0	435442	0.0000	0.0000
19	148.0	463100.0	30.6	0	435442	0.0000	0.0000
20	148.0	463100.0	0.3001	0	435442	0.0000	0.0000

HEATING CURVES SUMMARY

Eqp # 13 Unit type : HTXR Unit name: TT-628

Stream 6225

NP	Temp C	Pres Pa	Del H kW	Vapor kg/h	Liquid kg/h	Vap mole frac.	Vap mass frac.
1	124.8	394100.0	5.60E+003	0	435442	0.0000	0.0000
2	124.2	390468.4	5.30E+003	0	435442	0.0000	0.0000
3	123.6	386836.8	5.01E+003	0	435442	0.0000	0.0000
4	123.1	383205.2	4.71E+003	0	435442	0.0000	0.0000
5	122.5	379573.7	4.42E+003	0	435442	0.0000	0.0000
6	121.9	375942.1	4.12E+003	0	435442	0.0000	0.0000
7	121.3	372310.5	3.83E+003	0	435442	0.0000	0.0000
8	120.7	368678.9	3.53E+003	0	435442	0.0000	0.0000
9	120.2	365047.3	3.24E+003	0	435442	0.0000	0.0000
10	119.6	361415.8	2.94E+003	0	435442	0.0000	0.0000
11	119.0	357784.2	2.65E+003	0	435442	0.0000	0.0000
12	118.4	354152.6	2.35E+003	0	435442	0.0000	0.0000
13	117.9	350521.1	2.06E+003	0	435442	0.0000	0.0000
14	117.3	346889.5	1.77E+003	0	435442	0.0000	0.0000
15	116.7	343257.9	1.47E+003	0	435442	0.0000	0.0000
16	116.1	339626.3	1.18E+003	0	435442	0.0000	0.0000
17	115.5	335994.7	882.	0	435442	0.0000	0.0000
18	115.0	332363.2	588.	0	435442	0.0000	0.0000
19	114.4	328731.6	294.	0	435442	0.0000	0.0000
20	113.8	325100.0	0.000	0	435442	0.0000	0.0000

APPENDIX III
UTILITY SUMMARY

Table 4.1
Utilities Summary

Area	Steam: kg/h LP SERI	LP CSI	HP SERI	HP CSI	Electricity kW SERI	CSI	Cooling Water 10^3 kg/h SERI	CSI	Chilled Water 10^3 kg/h SERI	CSI	Fermentation Air Nm^3/h SERI	CSI
100 Wood Handling					6845	6845	91					
200 Pretreatment	13876	30400	18755	21000	263	188	1803	1920				
300 Xylose Fermentation					553	855	3055	3293	12	12	14023	8423
400 Cellulase Production	51	51			658	919		69	403	945	16923	22300
500 SSF					2054	1974	3658	2155	36	36	55777	10800
600 Ethanol Purification	77998			95194	290	316	2378	1296				
700 Off-site Tankage					79	79						
800 Wastewater Treatment					381	908	822	570				
900 Utilities and Miscellaneous	9553	9070			9662	7352	3514	3514	316	316		
Totals	101478	39521	18755	116194	20785	19437	15322	12817	768	1309	86724	41523
%difference		-61.1%		519.5%		-6.5%		-16.3%		70.5%		-52.1%

Notes:
1) CSI Area 100 electricity estimated as same as SERI 1991
2) Utilities Electricity consumption based on scaled utility requirements, and a chilled water system consuming 0.75 kW per ton of refrigeration.

Reasons for Difference from 1991 SERI Report:
1) Ethanol Purification steam higher because 1991 columns were undersized.
2) HP steam higher because there is more water to heat to 160°C, and ethanol purification uses HP, not LP Steam.
3) Cooling water reduced because of heat integration.
5) Chilled water increase due to need to cool recycle water for seed fermenters.
6) Fermentation air for 1991 SERI report included a second SSF seed train.

APPENDIX IV
COMPONENT BALANCES

FIGURE A.IV.1
ETHANOL BALANCE, KG/H

$$\text{ETHANOL RECOVERY} = \frac{21{,}124}{21{,}685} = 97.4\%$$

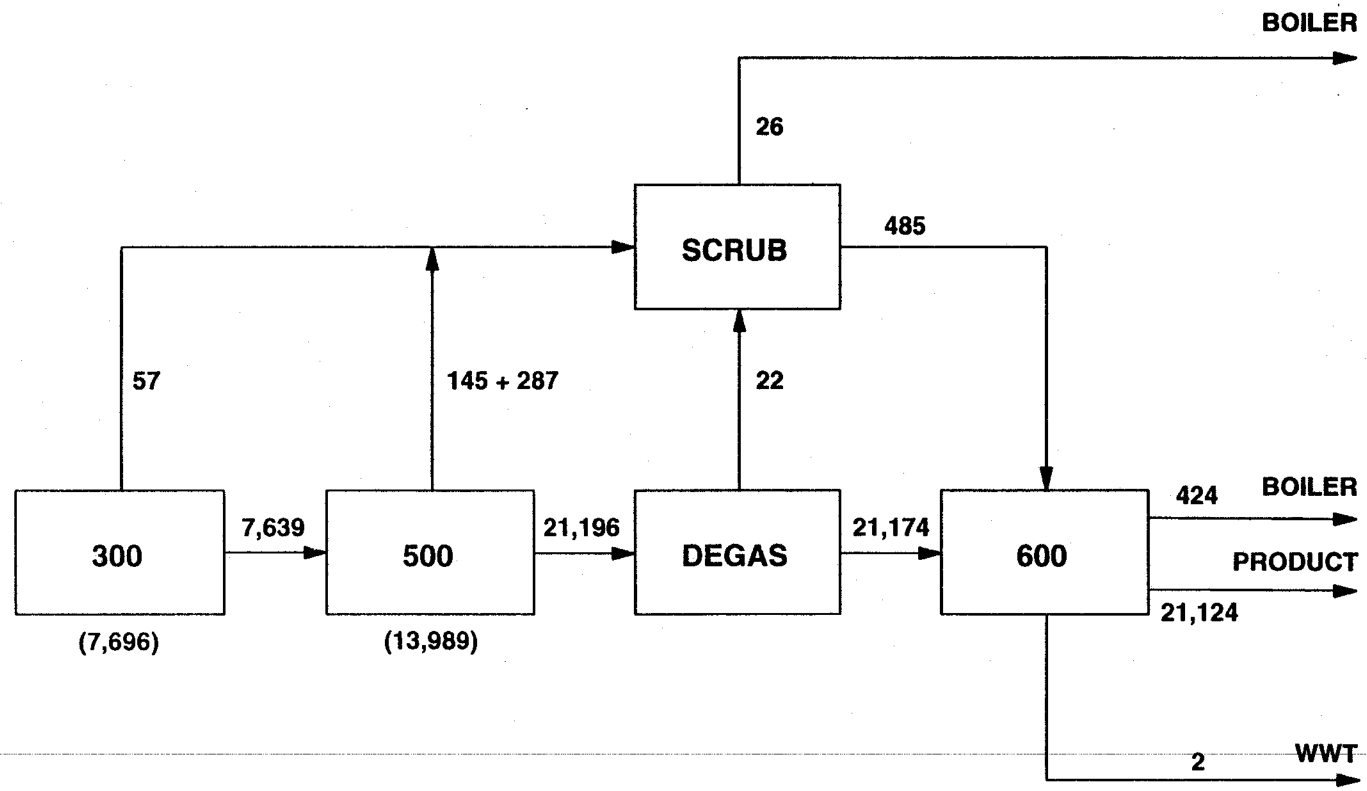
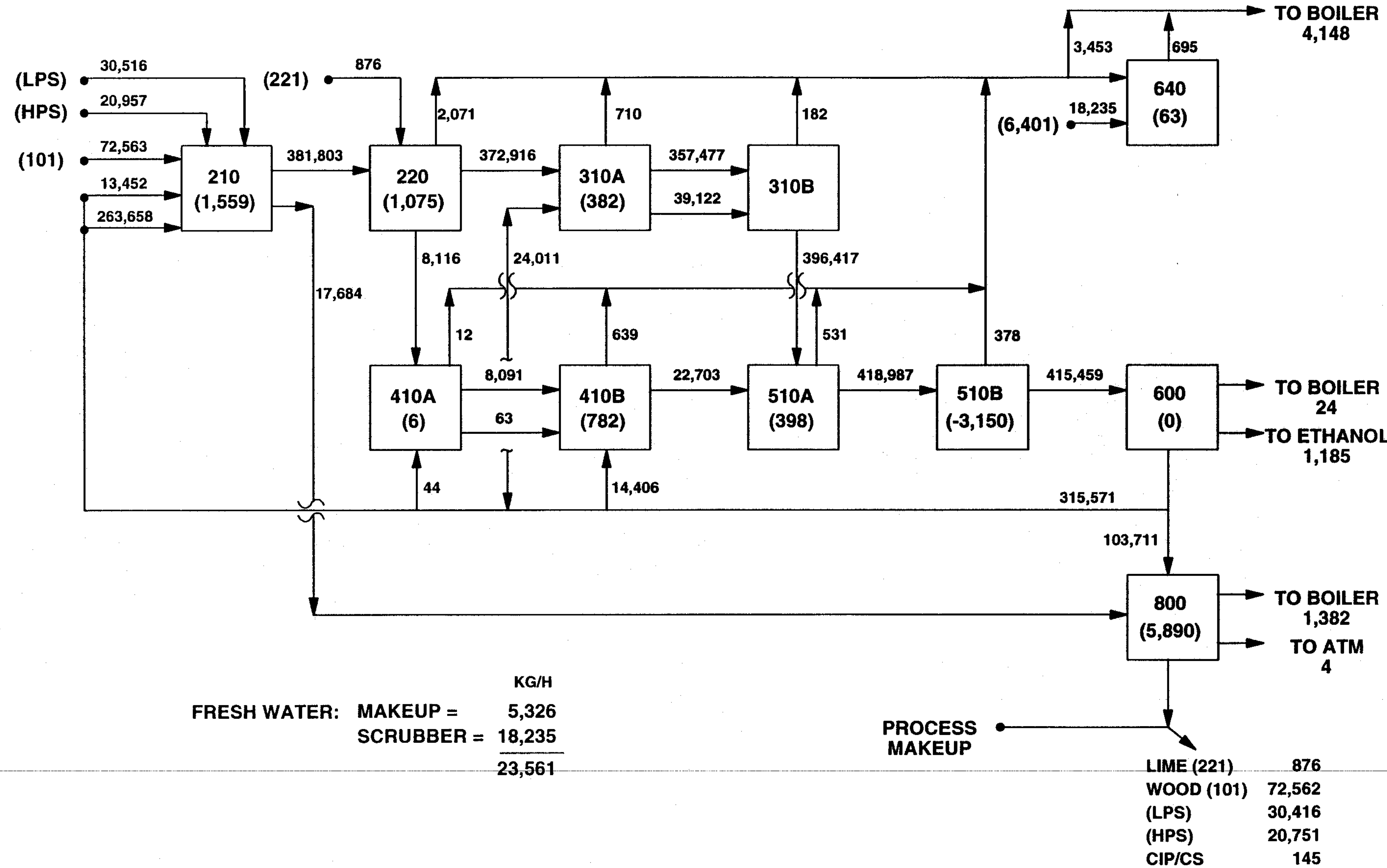


FIGURE A.IV.2
WATER BALANCE, KG/H



		KG/H
FRESH WATER:	MAKEUP =	5,326
	SCRUBBER =	18,235
		23,561

CHEM SYSTEMS

G:\94Q3\7951\RP\JJP2(dr)

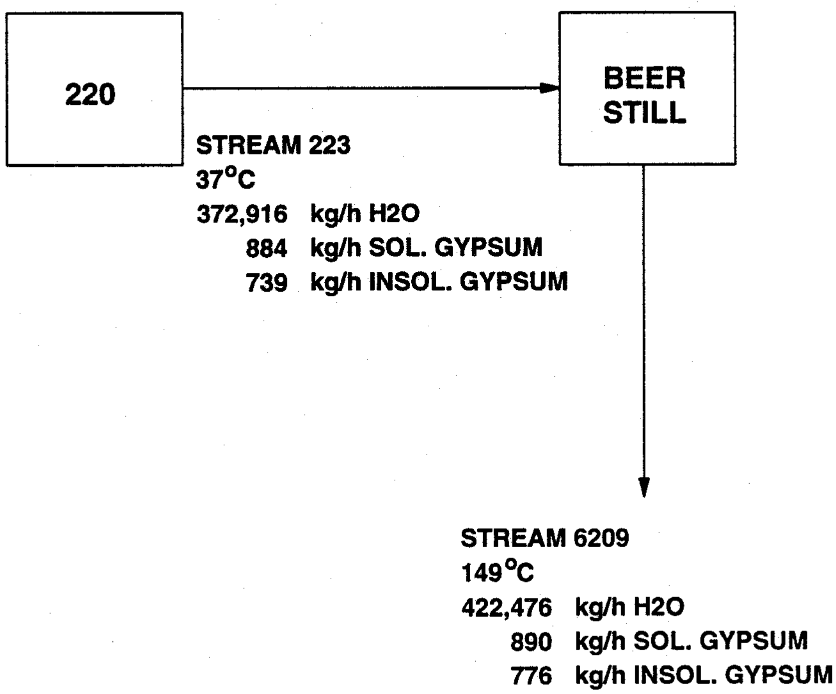
TABLE A.IV.1
WATER BALANCE SUMMARY

The following summarizes the water balance for the plant. The water balance below does not include BFW makeup for the turbogenerator (co-gen) excess steam, nor makeup for wood washing water. Wood washing water purge should not be recycled due to the presence of ash and other contaminants.

	kg/h
Process makeup[1]	5,330
Somber	18,235
Utility boiler feed water[2]	20,863
Cooling tower water lesser[3]	551,131
Chilled water makeup	1,309
Total	**596,868**

(1) Includes any steam used for direct contact, such as in Area 200.
(2) Assumes 100 percent recycle of condensate, with 20 percent loss of condensate.
(3) Assumes 4.3 percent losses in circuit.
(4) Assumes 0.1 percent losses in circuit.

FIGURE A.IV.3
GYPSUM BALANCE



Water addition prior to beer still
is enough to offset lower solubility
due to temperature range.
Plating should be minimal.

APPENDIX VII
STEAM BALANCE

Job Name: STMBALRV

Date: 10-26-94 Time: 11:19

Steam balance for CSI case, Radian design

FLOWSHEET SUMMARY

Equipment		Label	Stream Numbers			
1	FIRE	HB-901	6	-7		
2	EXPN	GZ-911(HT25)	10	-9		
3	EXPN	GZ-911(LT10)	13	-16		
4	DIVI		8	-10	-11	-18
5	DIVI		9	-13	-14	-15
6	HTXR		11	5	-12	-6
7	HTXR		16	-17		
8	PUMP	PP-901	2	-3		
9	PUMP	PP-908	4	-5		
10	MIXE	GV-906	15	12	3	-4
11	MIXE		17	1	-2	
12	EXPN	GZ-911(HT25)	7	-8		

Stream Connections

Stream	Equipment From	Equipment To	Stream	Equipment From	Equipment To	Stream	Equipment From	Equipment To
1		11	7	1	12	13	5	3
2	11	8	8	12	4	14	5	
3	8	10	9	2	5	15	5	10
4	10	9	10	4	2	16	3	7
5	9	6	11	4	6	17	7	11
6	6	1	12	6	10	18	4	

Equipment Calculation Sequence
11 8 10 9 6 1 12 4 2 5 3 7

Equipment Recycle Sequence
11 8 10 9 6 1 12 4 2 5 3 7

Recycle Cut Streams
17 15 12 11

Recycle Convergence Method: Direct Substitution

Max. loop iterations 40

Recycle Convergence Tolerance

Flow rate	1.000E-003
Temperature	1.000E-003
Pressure	1.000E-003

Enthalpy	1.000E-003
Vapor frac.	1.000E-003

Recycle calculation has converged.

COMPONENTS

	ID #	Name
1	62	Water

THERMODYNAMICS

K-value model	:	SRK Water/Hydrocarbon immiscible
Enthalpy model	:	SRK
Liquid density	:	Library

Overall Mass Balance

	kmol/h		kg/h	
	Input	Output	Input	Output
Water	8643.560	8643.560	155713.722	155713.722
Total	8643.560	8643.560	155713.725	155713.725

EQUIPMENT SUMMARIES

Fired Heater Summary

Equip. ^o.	1
Name	HB-901
Temperature Out C	510.0000
Pressure Drop Pa	2.6117e+006
Heat Absorbed kW	171203.1406
Fuel Usage(SCF)	865433.3125

Expander Summary

Equip. No.	2	3	12
Name	GZ-911(HT25)	GZ-911(LT10)	GZ-911(HT25)
Type of Expander:	2	1	1
Pressure out Pa	461328.4062	11858.9873	1.1811e+006
Efficiency	0.7911	0.8181	0.8470
Actual power kW	-3469.1267	-4120.9185	-30505.1445
Cp/Cv	1.4712	1.5089	1.4167
Ideal Cp/Cv	1.2490	1.2530	1.2213
Theoretical power kW		-5037.1821	-36015.5195

Divider Summary

Equip. No.	4	5
Name		
Split based on	3	3
Output stream #2	20230.2188	39521.0508
Output stream #3	116192.6719	17312.2598

Heat Exchanger Summary

Equip. No.	6	7
Name		
Pressure drop 1 Pa	82530.2812	6.8948
Pressure drop 2 Pa	6.8948	
T Out Str 1 C	154.3889	
VF Out Str 1		0.0010
Calc Ht Duty kW	12673.4424	-18888.0195
LMTD C	61.1518	
LMTD Corr F	1.0000	

EQUIPMENT SUMMARIES

Pump Summary

Equip. No.		8	9
Name		PP-901	PP-908
Output pressure	Pa	999947.0625	1.3053e+007
Efficiency		0.8000	0.8000
Calculated power	kW	65.3448	1037.8427

Mixer Summary

Equip. No.		10	11
Name		GV-906	
Output Pressure	Pa	429060.9062	11858.9873

STREAM PROPERTIES

Stream No.	1	2	3	4
Name	process rtn			
- - Overall - -				
Mass flow kg/h	155713.7247	188077.5545	188077.5545	225620.0200
Temp C	49.1315	49.1315	49.5454	105.7234
Pres Pa	11858.9873	11858.9873	999947.0625	429060.9062
Vapor mass fraction	1.000E-005	0.0000	0.0000	0.0000
Enth kW	8899.	1.077E+004	1.083E+004	2.781E+004
Std. sp gr , wtr = 1	1.000	1.000	1.000	1.000
Std. sp gr , air = 1	0.622	0.622	0.622	0.622
Average mol wt	18.0150	18.0150	18.0150	18.0150
Actual dens kg/m3	879.378	988.189	988.003	953.597
Actual vol m3/h	177.0725	190.3255	190.3612	236.5989

STREAM PROPERTIES

Stream No.	5	6	7	8
Name				
- - Overall - -				
Mass flow kg/h	225620.0200	225620.0200	225620.0200	225620.0200
Temp C	109.6322	156.7491	510.0000	237.8812
Pres Pa	13053159.0000	13053153.0000	10441417.0000	1181072.3750
Vapor mass fraction	0.0000	0.0000	1.000	1.000
Enth kW	2.885E+004	4.152E+004	2.127E+005	1.822E+005
Std. sp gr , wtr = 1	1.000	1.000	1.000	1.000
Std. sp gr , air = 1	0.622	0.622	0.622	0.622
Average mol wt	18.0150	18.0150	18.0150	18.0150
Actual dens kg/m3	950.639	910.182	31.360	5.221
Actual vol m3/h	237.3351	247.8846	7194.4971	43211.6778

STREAM PROPERTIES

Stream No.	9	10	11	12
Name				
- - Overall - -				
Mass flow kg/h	89197.1394	89197.1394	20230.2197	20230.2197
Temp C	159.2655	237.8812	237.8812	154.3889
Pres Pa	461328.4062	1181072.3750	1181072.3750	1098542.1250
Vapor mass fraction	1.000	1.000	1.000	0.0000
Enth kW	6.857E+004	7.204E+004	1.634E+004	3665.
Std. sp gr , wtr = 1	1.000	1.000	1.000	1.000
Std. sp gr , air = 1	0.622	0.622	0.622	0.622
Average mol wt	18.0150	18.0150	18.0150	18.0150
Actual dens kg/m3	2.373	5.221	5.221	912.422
Actual vol m3/h	37582.8090	17083.4031	3874.5751	22.1720

STREAM PROPERTIES

Stream No.	13	14	15	16
Name		LP STM		
- - Overall - -				
Mass flow kg/h	32363.8298	39521.0496	17312.2600	32363.8262
Temp C	159.2655	159.2655	159.2655	49.1315
Pres Pa	461328.4062	461328.4062	461328.4062	11858.9873
Vapor mass fraction	1.000	1.000	1.000	0.88216
Enth kW	2.488E+004	3.038E+004	1.331E+004	2.076E+004
Std. sp gr , wtr = 1	1.000	1.000	1.000	1.000
Std. sp gr , air = 1	0.622	0.622	0.622	0.622
Average mol wt	18.0150	18.0150	18.0150	18.0150
Actual dens kg/m3	2.373	2.373	2.373	0.091
Actual vol m3/h	13636.3527	16652.0154	7294.4422	357520.2649

STREAM PROPERTIES

Stream No.	17	18
Name		MP STM
- - Overall - -		
Mass flow kg/h	32363.8262	116192.6751
Temp C	49.1198	237.8812
Pres Pa	11852.0928	1181072.3750
Vapor mass fraction	0.0000	1.000
Enth kW	1870.	9.384E+004
Std. sp gr , wtr = 1	1.000	1.000
Std. sp gr , air = 1	0.622	0.622
Average mol wt	18.0150	18.0150
Actual dens kg/m3	988.194	5.221
Actual vol m3/h	32.7505	22253.7000

FLOW SUMMARIES

Stream No.	1	2	3	4
Stream Name	process rtn			
Temp C	49.1315	49.1315	49.5454	105.7234
Pres Pa	11858.9873	11858.9873	999947.0625	429060.9062
Enth kW	8898.6	10769.	10834.	27808.
Vapor mass fraction	1.0000E-005	0.00000	0.00000	0.00000
Total kg/h	155713.7247	188077.5545	188077.5545	225620.0200
Flowrates in kg/h				
Water	155713.7247	188077.5545	188077.5545	225620.0200

Stream No.	5	6	7	8
Stream Name				
Temp C	109.6322	156.7491	510.0000	237.8812
Pres Pa	13053159.0000	13053153.0000	10441417.0000	1181072.3750
Enth kW	28846.	41519.	2.1272E+005	1.8222E+005
Vapor mass fraction	0.00000	0.00000	1.0000	1.0000
Total kg/h	225620.0200	225620.0200	225620.0200	225620.0200
Flowrates in kg/h				
Water	225620.0200	225620.0200	225620.0200	225620.0200

Stream No.	9	10	11	12
Stream Name				
Temp C	159.2655	237.8812	237.8812	154.3889
Pres Pa	461328.4062	1181072.3750	1181072.3750	1098542.1250
Enth kW	68569.	72038.	16338.	3665.1
Vapor mass fraction	1.0000	1.0000	1.0000	0.00000
Total kg/h	89197.1394	89197.1394	20230.2197	20230.2197
Flowrates in kg/h				
Water	89197.1394	89197.1394	20230.2197	20230.2197

Stream No.	13	14	15	16
Stream Name		LP STM		
Temp C	159.2655	159.2655	159.2655	49.1315
Pres Pa	461328.4062	461328.4062	461328.4062	11858.9873
Enth kW	24879.	30381.	13309.	20758.
Vapor mass fraction	1.0000	1.0000	1.0000	0.882157
Total kg/h	32363.8298	39521.0496	17312.2600	32363.8262
Flowrates in kg/h				
Water	32363.8298	39521.0496	17312.2600	32363.8262

Stream No.	17	18
Stream Name		MP STM
Temp C	49.1198	237.8812
Pres Pa	11852.0928	1181072.3750
Enth kW	1870.3	93840.
Vapor mass fraction	0.00000	1.0000
Total kg/h	32363.8262	116192.6751
Flowrates in kg/h		
Water	32363.8262	116192.6751

APPENDIX VIII
SENSITIVITY ANALYSIS RESULTS

Table 4.1
Utilities Summary: Sensitivity

	Steam: kg/h				Electricity		Cooling Water		Chilled Water		Fermentation Air	
	LP		HP		kW		10^3 kg/h		10^3 kg/h		Nm^3/h	
Area	Base	Sens	Base	Sens	Base	Sens	Base	Sens	Base	Sens	Base	Sens
100 Wood Handling	0		0		6845	6845	0		0		0	
200 Pretreatment	30400	30300	21000	20200	188	188	1920	1920	0		0	
300 Xylose Fermentatio	0		0		855	793	3293	2952	12	12	8423	0
400 Cellulase Productio	51	51	0		919	919	69	69	945	945	22300	22300
500 SSF	0		0		1974	1557	2155	1740	36	36	10800	0
600 Ethanol Purification	0		95194	59014	316	316	1296	828	0		0	
700 Off-site Tankage	0		0		79	79	0		0		0	
800 Wastewater Treatm	0		0		908	908	570	570	0		0	
900 Utilities and Miscella	9070	9070	0		7352	4856	3514	3514	316	316	0	
Totals	39521	39421	116194	79214	19437	16461	12817	11594	1309	1309	41523	22300
%difference		-0.3%		-31.8%		-15.3%		-9.5%		0.0%		-46.3%
Unit consumption per kg	1.9522	1.4983	5.7394	3.0108	0.9601	0.6257	0.6331	0.4407	0.0647	0.0497	2.0510	0.8476
		-23.25%		-47.54%		-34.83%		-30.40%		-23.05%		-58.67%

Ethanol Production, kg/h

Base:	20245
Sensitivity:	26310

EQUIPMENT COST BY SECTION

PLANT AREA	Chem Systems BASE EQUIPMENT COST ($ MM)	INSTALLED EQUIPMENT COST ($ MM)
ISBL		
100 WOOD HANDLING	2.48	3.20
200 PREHYDROLYSIS	5.19	7.75
300 XYLOSE FERMENTATION	1.02	1.45
400 CELLULASE PRODUCTION	1.03	1.50
500 SSF	4.74	7.34
600 ETHANOL RECOVERY	3.80	6.57
Total	**18.26**	**27.81**
OSBL		
700 OFF-SITE TANKAGE	1.39	2.12
800 WASTE TREATMENT	4.16	5.70
900 UTILITIES		
Boiler Feed Water and Boiler Package	19.57	25.68
Process Water	0.20	0.43
Turbogenerator	6.38	9.58
Cooling Water	2.40	2.88
Chilled Water Package	1.02	1.23
Plant and Fermentation Air	2.96	3.63
CIP/CS	0.17	0.30
BUILDINGS		1.59
SITE DEVELOPMENT		3.58
ADDITIONAL PIPING		1.79
Total	**38.27**	**58.51**
Total Equipment Cost	**56.53**	**86.32**
Proratable Costs		8.63
Field Expenses		8.63
Home Office Construction and Fee		21.58
Contingency		2.59
Total Fixed Capital Investment		**127.76**
Owner's Cost		12.78
Total Capital Investment		**140.53**

OUTPUT BY SECTION

PLANT AREA		*Chem Systems* BASE EQUIPMENT COST ($)	INSTALLED EQUIPMENT COST ($)
	100 WOOD HANDLING		
pp-101	Flume	10,496	14,695
GS-103	Magnetic Chip Cleaner	10,882	13,058
GM-101A/B/S	Front End Loaders	412,152	494,582
GS-101	Radial Stacking Conveyor	131,984	184,777
GS-102	Belt Conveyer	202,589	283,624
GS-104	Milled Chip Belt Conveyor	42,272	59,181
GY-101A/B/C/D	Wood Chip Unloader with Scale	166,594	199,913
GG-101A/B/C/D	Disk Refiner	1,500,000	1,950,000
	TOTAL($ MM)	2.48	3.20
	200 PREHYDROLYSIS		
GS-223	Lime Unloading Conveyor	19,022	26,631
T-201	Sulfuric Acid Storage	45,371	54,445
T-203	Blowdown Tank	36,337	43,605
T-206	Neutralization Reaction Tank	63,956	76,747
T-220*	Lime Slurry Tank	35,387	42,465
pp-201	Sulfuric Acid	3,900	7,799
pp-202	Hydrolyzate	68,163	95,429
pp-203A/S	Neutralized Hydrolyzate	109,305	153,027
pp-221*	Slurry Metering Pump	7,691	10,767
TT-220	Feed Cooler	127,403	267,547
GA-201	Line Mixer	222	267
GA-203	Blowdown Tank Agitator	19,629	23,555
GA-213	Neutralization Tank Agitator	29,497	35,396
GF-201	Desiccant Air Filter	1,057	1,480
MR-201/MR-202	Pre-Hydrolysis System (w/ plug screw feeder)	4,560,000	6,840,000
GS-226*	Rail Car weigh station	60,000	72,000
	TOTAL ($ MM)	5.19	7.75
	300 XYLOSE FERMENTATION		
	Seed Fermenters		
FM-305/10	Xylose Seed Fermenter	0	0
FM-305/10	Xylose Seed Fermenter	0	0
FM-305/10	Xylose Seed Fermenter	0	0
FM-305/10	Xylose Seed Fermenter	0	0
FM-305/10	Xylose Seed Fermenter	0	0
FM-305/10	Xylose Seed Fermenter	0	0
	Total ($ MM)	0.00	0.00
FM-303	Xylose Fermenters	0.73	1.03
	Remaining Equipment		
T-301	Seed Hold Tank	0	0
T-321	Base Tank	14,203	39,768
pp-303*	Xylose Fermenter Product Pump	98,832	138,365
TT-301A*	Water Cooler	29,567	62,091
COILS	Xylose Fermentation Coils	7,682	19,206
COILS	Xylose Seed Fermentation Coils	0	0
GA-301	Seed Hold Tank Agitator	0	0
GA-303A-H	Xylose Fermenter Agitator	139,152	166,982
GA-305	First Seed Vessel Agitator	0	0
GA-306	Second Seed Vessel Agitator	0	0
GA-307	Third Seed Vessel Agitator	0	0
GA-308	Fourth Seed Vessel Agitator	0	0
	Total ($ MM)	0.29	0.43
	TOTAL ($ MM)	1.02	1.45

	400 CELLULASE PRODUCTION		
	Seed Fermenters		
FM-401/4	Cellulase Seed Fermenter	70,710	98,994
FM-401/4	Cellulase Seed Fermenter	17,897	26,846
FM-401/4	Cellulase Seed Fermenter	3,702	5,553
FM-401/4	Cellulase Seed Fermenter	766	1,149
	Total ($ MM)	**0.09**	**0.13**
FM-400	**Cellulase Fermenter ($ MM)**	**0.25**	**0.41**
	Remaining Equipment		
T-400	Media Prep Tank	8,490	19,526
T-403A/B	Antifoam Tank	7,707	17,725
T-405	Sterile Feed Tank	79,361	111,105
T-410A/B	Cellulase Hold Tank	117,757	188,410
pp-401A/S	Feed	43,470	60,858
pp-403A/S	Fermenter Recycle	69,790	97,706
pp-411A/S	Prep Tank	2,416	6,764
pp-412	Cellulase Feed	13,329	18,661
TT-401A*	Water Cooler	310	651
TT-401B*	Water Cooler	78	163
TT-402A	Water Cooler	14,634	30,731
TT-402B*	Water Cooler	3,884	8,157
COILS	Cellulase Fermentation Coils	4,819	12,048
COILS	Cellulase Seed Fermentation Coils	29	73
GA-400	Prep Tank Agitator	5,483	6,580
GA-401A/B/C	Fermenter Agitator	127,403	152,884
GA-405	Feed Tank Agitator	64,827	77,792
GA-410	Hold Tank Agitator	49,988	59,986
GA-411	First Seed Vessel Agitator	54,623	65,548
GA-412	Second Seed Vessel Agitator	13,549	16,259
GA-413	Third Seed Vessel Agitator	4,406	5,287
	Total ($ MM)	**0.69**	**0.96**
	TOTAL ($ MM)	**1.03**	**1.50**
	500 SSF		
	Seed Fermenters		
FM-501/6	SSF Seed Fermenter (S.c.)	0	0
FM-501/6	SSF Seed Fermenter (S.c.)	0	0
FM-501/6	SSF Seed Fermenter (S.c.)	0	0
FM-501/6	SSF Seed Fermenter (S.c.)	0	0
FM-501/6	SSF Seed Fermenter (S.c.)	0	0
FM-501/6	SSF Seed Fermenter (S.c.)	0	0
	Total ($ MM)	**0.00**	**0.00**
FM-500	**SSF Fermenter ($ MM)**	**3.93**	**6.29**
	Remaining Equipment		
T-501A	Seed Hold Tank (S.c.)	0	0
pp-501*	SSF Seed Transfer Pump	0	0
pp-505	Beer Transfer	353,712	495,197
COILS	SSF Fermentation Coils	4,771	11,928
COILS	SSF Seed Fermentation Coils	0	0
GA-500A-AA	SSF Fermenter Agitator	447,273	536,728
GA-501A	Seed Hold Tank Agitator (S.c.)	0	0
GA-510A	First Seed Vessel Agitator (S.c.)	0	0
GA-511A	Second Seed Vessel Agitator (S.c.)	0	0
GA-512A	Third Seed Vessel Agitator (S.c.)	0	0
GA-513A	Fourth Seed Vessel Agitator (S.c.)	0	0
	Total ($ MM)	**0.81**	**1.04**
	TOTAL ($ MM)	**4.74**	**7.34**

600 ETHANOL RECOVERY

AS-602	**Rectification Column**	**0.00**	**0.00**
PSA-600	**PSA Package**	**1.57**	**1.96**
	Remaining Equipment		
AS-601	Beer Column	476,685	1,430,054
AS-640*	Vent Scrubber	159,887	479,662
T-601	Degasser Drum	43,374	60,723
T-602	Beer Column Reflux Drum	9,183	25,713
T-603	Fusel Oil Decanter	5,208	14,584
T-605	Rectification Column Reflux Drum	0	0
T-607*	Extraction Still Reflux Drum	9,183	25,713
T-630	Recycled Water Tank	23,590	54,258
pp-601	Beer Column Bottoms	82,244	115,141
pp-603	Beer Column Reflux	11,044	30,922
pp-604A/S	Wash Return	2,416	6,764
pp-605A/S	Fusel Oil	2,416	6,764
pp-607	Rectification Column Bottoms	0	0
pp-608	Rectification Column Reflux	0	0
pp-621	Ethanol Storage	2,066	5,785
pp-622	Bottoms to WWT	1,208	3,382
pp-631	Recycled Water	20,454	57,272
pp-632A/S	Sump	3,033	8,493
pp-641*	Vent Scrubber Return Ethanol	3,430	9,604
GS-611A/B	Sludge Screws	39,850	55,790
TT-607	Fusel Oil Cooler	1,222	2,567
TT-613	Mash Trim Heater	142,943	300,181
TT-615	Flash/Mash Exchanger	63,520	133,392
TT-616	Scrub/Flash Exchanger	23,864	50,113
TT-621	Beer Column Reboiler	174,677	366,822
TT-622	Beer Column Condenser	160,976	338,049
TT-623	Rectification Column O/H Condenser	0	0
TT-624	Beer Column O/H Trim. Condenser	0	0
TT-625	Beer Column Bottoms/Scrub Exchanger	4,150	8,714
TT-626	Rectification Column O/H Trim. Condenser	0	0
TT-627	Rectification Column Bottoms Trim Reboiler	0	0
TT-628	Beer Still Bottoms Trim Cooler	0	0
TT-629	Mash Beer Bottoms Exchanger	32,685	68,639
GC-609A/B/C	Centrifuge	713,340	927,342
FAN-640*	FAN	19,272	26,981
	Total ($ MM)	**2.23**	**4.61**
	TOTAL ($ MM)	**3.80**	**6.57**

700 OFF-SITE TANKAGE

T-701A/B	Ethanol Product Tank	669,242	936,938
T-703	Sulfuric Acid Storage Tank	119,564	143,477
T-704	Fire Water Tank	143,506	200,909
T-706A/B	NH3 Storage Tank	85,160	238,449
T-707	Antifoam Storage Tank	23,611	54,305
T-708	Diesel Fuel Tank	31,935	44,709
T-710	Gasoline Storage Tank	64,771	90,679
T-720	Corn Steep Liquor Tank	37,519	52,527
T-730*	Lime Slurry Storage Tank	112,590	135,108
pp-701A/B/S	Ethanol Export	13,535	37,898
pp-703A/S	Sulfuric Acid Transfer	8,492	16,983
pp-704A/S	Fire Water	17,897	50,111
pp-706A/S	NH3 Transfer	6,903	19,328
pp-707A/S	Antifoam Transfer	2,416	6,764
pp-708A/S	Diesel Fuel	3,284	9,195
pp-710A/S	Gasoline Blending	2,416	6,764
pp-720A/S	Corn Steep Liquor Transfer	8,079	16,158
GF-703	Desiccant Air Filter	41,004	57,405
	TOTAL ($ MM)	**1.39**	**2.12**

800 WASTE TREATMENT

MS-806	Offgas K.O. Suction Pot	12,349	28,402
MS-809	Offgas Knock Out Drum	12,349	28,402
MS-810	LP Vent Knock Out Drum	5,197	11,952
T-803	Equalization Tank	178,693	250,170
T-804	Anaerobic Reactor	921,473	1,290,063
T-807	Biotreater	1,115,417	1,561,583
800*	Pressure Swing Adsorption Oxygen Generator	494,974	593,969
pp-808A/S	Primary Heat Exchanger Influent Pump	3,315	9,283
pp-809A/S	Seconday Heat Exchanger Influent Pump	3,315	9,283
pp-813A*	Return Activated Sludge	6,729	13,459
pp-813B*	Waste Activated Sludge	4,848	9,697
pp-816A/S	Final Effluent	13,463	37,695
GS-801	Sludge Screws	27,217	38,103
new*	Bar Screens	55,363	66,436
TT-801	Offgas Cooler	14,681	30,829
TT-802	Feed Cooler(Primary Heat Exchanger)	51,518	108,188
TT-803A	Seconday Heat Exchanger A: Cooling Water	79,808	167,598
GC-801	Sludge Centrifuge	126,751	164,776
GO-806	Offgas Burner	19,805	23,766
GV-808	Secondary Clarifier	93,702	112,442
PB-810	Offgass Blower	73,575	103,005
PB-817A/S	LP Vent Blower	144,575	202,405
OSBL*	Equalization Tank Mixers	65,390	78,467
OSBL*	Nutrient Feed System	23,165	27,798
OSBL*	Anaerobic Mixers	331,077	397,292
OSBL*	Aeration Tank Mixers	108,361	130,033
OSBL*	Mist System and Backup Carbon	166,311	199,574
OSBL*	Biofilter	6,435	7,722
	TOTAL ($ MM)	4.16	5.70

900 [illegible]drWater

MS-902	Blowdown Flash Drum	5,601	15,683
MS-903	Hydrazine Drum	5,589	8,383
MS-904	Condensate Surge Drum	25,010	70,029
T-930	Condensate Collection Tank	19,179	53,701
pp-906A/S	Blowdown	3,158	8,842
pp-907	Hydrazine Transfer	1,875	3,750
pp-909A/S	Dearator Feed	109,826	153,756
pp-910A/S	Condensate	10,818	30,290
GU-903A/B	Demineralizers	626,406	751,687
GU-904A/S	Condensate Polisher	203,246	243,896
GU-907	Hydrazine Addition Package	15,243	18,292
GU-908	Ammonia Addition Package	15,243	18,292
GU-909	Phosphate Addition Package	15,243	18,292
GV-906	Dearator	135,159	378,445
pp-908A/S	Boiler Feed Water	109,826	153,756
HB-901A	Steam Boiler	18,270,638	23,751,829
	Total ($ MM)	**19.57**	**25.68**
	Process Water		
GF-901	Sand Filter	40,243	56,340
T-901	Process Water Tank	53,866	75,413
T-905	Backwash Transfer Tank	24,712	56,838
pp-902A/S	Process Water Transfer	18,990	53,171
pp-903A/S	Process Water Circulating	27,080	75,823
pp-904A/B	Backwash Feed	22,920	64,175
pp-905A/B	Backwash Transfer	2,817	7,888
pp-913A/S	Well Water	14,337	40,144
	Total ($ MM)	**0.20**	**0.43**
	Turbogenerator		
pp-901A/S	Turbine Condensate	4,753	13,309
GZ-911	Turbo Generator	6,379,798	9,569,696
	Total ($ MM)	**6.38**	**9.58**
	Cooling Water		
GT-912	Cooling Tower System	2,401,356	2,881,627
	Total ($ MM)	**2.40**	**2.88**
PK-951	**Chilled Water Package.**	**1.02**	**1.23**
	Plant and Fermentation Air		
MS-906	Plant Air Receiver	19,945	55,845
MS-907	Instrument Air Receiver	19,945	55,845
GY-910	Instrument Air Dryer	24,412	34,177
PC-911	Air Compressor	55,258	71,835
PK-950A/B/S	Air Compressor Package(fermentation)	2,842,089	3,410,507
	Total ($ MM)	**2.96**	**3.63**
	CIP/CS		
T-961	Cleaning Tank	24,434	56,199
T-960	Sterilization Tank	40,458	60,686
T-963	Sterile Rinse Water Tank	24,434	56,199
pp-960A/S	Supply	4,660	9,321
pp-965A/B/C/S	CIP/CS Sump	4,831	13,528
GA-960	Sterilization Tank Agitator	12,417	14,900
GA-961	Cleanig Tank Agitator	12,417	14,900
T-953	Sterile Water Tank	40,458	60,686
pp-953	Sterile Water	1,950	3,900
TT-953	Water Sterilizer	3,410	7,162
	Total ($ MM)	**0.17**	**0.30**
	TOTAL ($ MM)	**32.72**	**43.73**
TOTAL		**56.527978**	**79.36**

TABLE VI.C.1
PRICING BASIS
(dollars per metric ton, fourth quarter 1993)

Wood (dry)	46
Sulfuric acid	72
Lime	50
Ammonia	129
Corn steep liquor	243
Nutrients	273
Antifoam	573
Glucose	1,168
Gasoline	165
Diesel	156
Solids disposal	(20)
Catalyst and chemicals	6

The cost of production estimate is shown in Table VI.C.2. The net raw materials is estimated to be $208 per metric ton (62 cents per gallon). Utilities are estimated to provide a credit of about $33 per metric ton (10 cents per gallon). The total variable cost is $176 per metric ton (52 cents per gallon).

Adding in the direct fixed costs ($27 per metric ton) and allocated fixed costs ($21/per metric ton) gives a total cash cost of production of $222 per metric ton or 66 cents per gallon.

Adding in the annual capital charge (20 percent of total investment) almost doubles the production cost. The resulting cost of denatured ethanol is estimated to be $430 per metric ton or $1.27 per gallon.

CHEM SYSTEMS

FAX COVER SHEET **FROM 914 631 8851**

Date:	January 10, 1994
Fax No:	(303) 231-~~1938~~ 1352
Company:	NREL
To:	Cindy Riley **CC:** AJN, DFB
From:	Jacques Pavlenyi
Pages to Follow:	2

Message:

Attached you will find our design for the flow between fermenters, valid for both xylose (area 300) and SSF (area 500).

It is our contention that a minimum of 18" height difference between successive fermenters is needed to allow for hydraulically unassisted flow. The attached sheet describes the reasoning behind this minimum. The following points bear notice:

1) A 14" pipe is desirable for the liquid flow rate; a larger pipe would decrease velocity to where flow is no longer turbulent, which may allow settling or other undesired flow regimes.

2) A minimum 6" clearance is necessary between a tank inlet and liquid level to prevent backflow or backup.

3) Looking at the plot plan, an equivalent pipe length of 320' is conservative. The attendant pressure drop of 0.138 psi/100' is also conservative, since I assumed water, and not a viscous mass. The cell mass and lignin would greatly increase fluid viscosity, which would make the pressure drop even higher.

The result is a MINIMUM 18" between successive fermenters, to provide enough gravity head for flow. The design value of 10" in the previous report is not sufficient, causing settling in pipes and, depending on initial design, no flow at all.

Admin. Assist.:

Chem Systems Inc
303 South Broadway Tarrytown NY 10591-5487
Telephone: (914) 631-2828 Telex: 221844 Facsimile: (914) 631-8851

Gravity flow would be acceptable for xylose fermentation, only because there are 7 fermenters; the first fermenter would be 10.5 feet higher than the last. For SSF, this would mean the first would be 40.5 feet higher than the first, requiring excessive architectural costs, as well as an extra 18 psi delta P on the first feed pump.

It is recommended that we replace gravity feed in the SSF with booster pumps every 6 fermenters, which would greatly diminish unnecessary architectural costs for fermenter elevating.

Please review the attached assumptions and conclusions, and let us know if and how you differ with any part of these. As is stands, the present setup will work, but at excessive construction costs, as well as a 120' SSF structure.

Sincerely;

Jacques Pavlenyi

Jacques Pavlenyi
Consultant

cc: Alan Nizamoff
Don Bari

CHEMSTATIONS

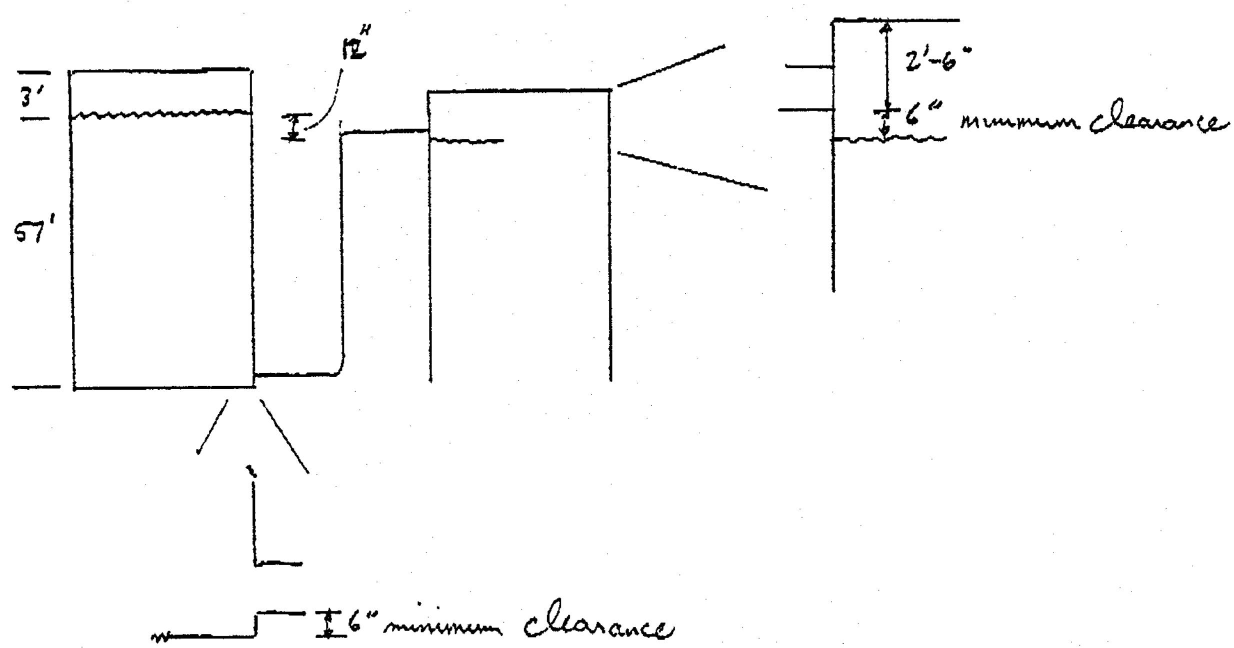
Engineering Software

CUSTOMER NREL

PROJECT 7951: BIOMASS TO ETHANOL

DATE 1/10/93

BY JJP



Pressure drop in pipe: 100 kg/s H_2O (~1600 gpm)

linear feet = 100'

90° bends : 4 @ 12' equivalent length each

inlet : 1 @ 40' equivalent length

outlet 1 @ 75' equivalent length

263' × 20% design factor

320' equivalent length

for 14" pipe, sch 40, $\Delta p = \frac{0.138 \text{ psi}}{100'} = \frac{0.318'}{100'} = \frac{3.82'' \text{ water}}{100'}$

Head loss $= \left(\frac{320}{100}\right)\left(3.82\right) = 12.2''$

add 6" for clearance: $\boxed{18''}$